CONTEMPORARY DISCOURSE ON NIGERIA'S ECONOMIC PROFILE

A Festschrift

In Honour of

PROFESSOR NYAUDOH UKPABIO NDAEYO

Editors

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Contemporary Science Education Issues in Nigeria Educational Development

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Abstract: *Science education is increasingly setting the pace for initiatives in the knowledge-driven economy. It holds the key for responsive changes to unlocking national development and solving challenging problems. The paper discusses contemporary science education issues on Nigeria's educational development. It considers factors posing as challenges in everyday teaching and learning in the context of publication plagiarism, imposition of foreign ideas and textbooks materials and paucity of quality science teachers for quality science teaching. The paper also looks at the way forward for science education development.*

Keywords: Science education, responsive changes, quality science teaching, science teachers

CITATION:
Etiubon, R. U. and Umanah, F. I. (2023). Contemporary Science Education Issues in Nigeria Educational Development. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp 257-263.

Introduction

Science Education is a sine-qua-non for attainment of deep knowledge in understanding the world we live in. The development of a nation hinges on the quality of its science education and science educators. Science education is a veritable tool for the scientific and technological development of any nation as it enhances scientific thinking and spurs students' curiosity about their environment. It enables students cultivate interest for inquiry and learning. Through inquiry, students recognize the nature of science and develop scientific knowledge and science process skills which help them evaluate the impact of scientific development. This prepares them to participate in science-related issues and enable them become lifelong learners in science education. Science education emphasizes the enhancing of students' scientific literacy through investigative activities that involves planning, measuring, observing, analyzing data, proof of scientific evidences, designing and evaluating procedures. This fact is hinged on the National Policy on Education (2014) that stipulate the goals of science education as; cultivate inquiring, rational mind for the conduct of good life and democracy, produce scientists for national development and service, studies in technology and technological development, provide knowledge and understanding of the complexity of the physical worlds in the forms and conduct of life. The objectives of teaching science include; knowledge of science in academic discipline acquisition of skills of

scientific method; clear explanations for societal issues through increased interest in science literacy and societal goals; meeting personal needs and career awareness (Kotkas *et al*., 2021). The major goal of science education is to develop scientifically literate individuals that are concerned with high competence for rational thoughts and actions. It is needed to expel ignorance, poor cultural practices and beliefs in the society which calls for effective science education that is relevant for the economic improvement of the society. Only the teacher well-groomed for scientific relevance can accomplish these feats. Without the teacher there is no growth and development in any nation. The teacher teaches, nurtures, mentors and directs every other profession; be it medical, engineering, teaching, law, pharmacy, journalism, nursing including non-science jobs. Attainment of the goals of science education is largely dependent on the quality of its science teachers. Only the teacher is able to produce scientifically literate, well informed, focused wholesome individual guided by ethics, processes and product of scientific knowledge acquired. Science teachers are prepared, produced and presented with skills of competence to share with others. It is not enough to know something, but very important to transfer knowledge and seek to satisfy others to make impact also. Impact must be felt to make meaning to others to accomplish feats. Science is applied in everyday life and utilized for humanity's sustenance. It deserves the best attention. Nigeria has since independence moved from one curriculum change to another. Students are desirous to have transformation creative knowledge and ability, but they somehow get 'shallow knowledge' of what they are taught. If the new curriculum does not address these challenges, then the set goals and objectives of the new curriculum will not be actualized in the educational sector.

Frequent changes in the curriculum does not allow for standardization and stable coherent course structure planning. Poor planning and implementation have militated against this. A change in curriculum has just been announced, and this should change the narrative for teaching and learning. Teachers and learners are beginning the process of rummaging and imagining new perspectives to promote and provide the needed educational focus to meet society's growing needs. Science curricular in use is overloaded with theoretical emphasis that makes learning boring. It cannot be covered within limited time. Because teachers want to cover the syllabus, they skip some important topics to meet with examination dates. Students hurriedly gloss through textbooks without engaging in hands-on activities, but rather memorize concepts and ideas difficult to regurgitate. They pass their subjects minimally. Hashimi (2014) posits that lack of scientific knowledge is a critical limitation to economic progress, hence, science education cannot be overemphasized.

With the poor state of education, tardy attitude of government towards emancipating Nigeria's educational sector, most science teachers and learners believe that the new curriculum is a defining one. It has the possibility to offer students, teachers, the society as a whole, the opportunity to break from its past of theory and rote memorization to initiate teaching and learning that makes for a wholesome creative person; who can think for himself and grow the economy. This will help the arduous task of rebuilding the educational sector. To achieve this, teachers and learners are expected to be trained and retrained adequately based on their different areas of specialization and capacity rather than their current status as low performing and semi-skilled professionals.

Some factors that have contributed hugely to educational retrogression and challenges in Nigeria is the learners' preoccupation with

publication plagiarism, foreign ideas and textbook imposition and paucity of Quality science teachers for science teaching.

Publication Plagiarism

Publication comes in the form of investigative writing and is a herculean task. Publishing research is highly intellectually demanding and requires rational thinking. Research advances the body of knowledge in all specialized fields of scientific endeavour demanding resilience in updating and refining knowledge. It enables out-of-the-box creative thinking environment and human capacity development. A new educational trend is evolving and negatively influencing educational ethos. It is plagiarism. Plagiarism in publications is becoming a serious challenging factor in the indices of education. It is a means of fleecing another person's knowledge without due acknowledgement. Plagiarism has taken centre stage without being questioned. It has been so ingrained that the few who genuinely want to avoid it are seen as misfits (Rogayan and Nebrida, 2019). The more they try, the more they are victimized, and more hurdles placed on their path, so as to make them relent on positive efforts. Many rights like promotion, conferences, workshop attendance are used to deny them opportunities so as to make them succumb to the new idea that plagiarism does not matter. There are colleagues that encourage others to play ball like them and stop losing what rightfully belong to them. Therefore, any teacher in an institution unwilling to be tainted with plagiarism is considered an unusual human being. Many science educator publishers do not want to take pains to write quality papers. This encourages plagiarism which is becoming rampant in article publishing because paper scrutiny is receiving less attention and lip service to kill ingenuity and quality works. Many authors find shrewd ways to engage in these. Many authors engaged in paper publications fall prey to publication plagiarism when under intense pressure to write for promotion. Some may remember to cite, others in a hurry may forget, while others unguardedly do so to their detriment. In most instance, articles for publication are rejected by journal editors. This anomaly has continued to soar in many tertiary institutions among teachers and students unabated. Lawal (2019) opine that plagiarism is a misappropriation of intellectual properties of others using individual's ideas, texts, words or phrases. In Nigeria, and the world over, there is inadequate in-depth knowledge of plagiarism spectrum in factors of plagiarism. This factor has remained unchallenged with ignorance used as the blame factor for plagiarism. Concerns of students grow about the real time consciousness on the need to obtain the necessary writing skills of academic and using them, while at the same time, they are faced with coursework and imminent submission deadlines (Orim, et al, 2013), hence, the plagiarism. That many Nigerian degree seeking students engage in plagiarism, even in climes where this seems a taboo and attracts delisting of institutions and individuals; the crime continues unchecked; and students get off the hook as teachers look the other way. Students will do anything to get away with this, particularly in the era of hi-tech tools. Nigeria's institution of higher learning have been so badly battered that it has become virtually impossible for authentic original work to survive the test of time.

The current approach to projects and article writing on investigative studies for submission as regards knowledge exposure is inadequate in meeting growing science demands. It has become a laborious way for classroom instruction that science teachers are finding difficult to change. This has eaten deep into the learners' psyche and created grave problems that have paralysed critical thinking of teachers and learners alike. Article publication, theses, dissertations, lecture notes, debates, quizzes, projects have become a serialized means of

bringing knowledge to students and teachers for some decades now. Most learning instructions use these means to drive knowledge which may not be real to students' learning, even though this has been the norm. Even when teachers and students claim that that they do not promote publication plagiarism; the constant pressure they give teachers and the special attention teachers give to the students various tasks forms still make loud statement that plagiarism has eaten deep into the fabric of learning in Nigeria tertiary institutions, and those doing this have a lot of ways they forage into the internet and dole out publishable information as plagiarized and profusely get accolades and honours for work not done. This transcends the academia. Non-thinking, non-challenging science teachers and students are celebrated as success icons and examples. Quick gain for promotion and attention without hard work has pauperized Nigerian researchers and created desperation among them. It is assumed that with the attainment of the status of professorship by any possible means; one quickly gains recognition both nationally and internationally to make impact among peers and colleagues for befitting acceptance. Students intentionally engage in the act of plagiarism, though some unknowingly do this as they do not understand what constitute citation, paraphrase or quotation (Idiata, et al, 2019). This has negatively impacted the quality of graduates produced and has had a damaging effect on intellectual property of authors. In the recent past, students' theses, dissertations, seminars and projects are carefully scrutinized and questioned to establish authenticity and independence of ideas. Until late 1990s, fewer teachers still question students' sources of information, before accepting it for publication. Teachers will not accept unauthenticated work from students if they were not sure of the source of information. Teachers were level-headed and dissociated themselves from students perceived as not doing authentic work as tainted. Because of the desire to hurriedly send students out of school and the programmes they are pursuing, plagiarism has become a herculean challenge to manage. Another factor hampering students' ethical success in contemporary Nigeria educational development is Reliance on foreign ideas.

Heavy Dependence of Education on Foreign ideas and Textbooks

Nigeria's school system relies heavily on foreign ideas which are daily imposed to make knowledge relevant. National educational development is hence, directly affected. Home grown science knowledge is all around the local environment and should be put into use in instruction. Textbook publishers engage in continuous publication of foreign books highly dependent on foreign knowledge and ideas for students' use as they make so much money from this. They blame the government for not providing credible alternatives. Peoples' original works are plagiarized for quick gains and profit. There is also the justification that stakeholders of education do not bother to comply with ethics of promoting quality standard education. Edema (2022) posits that western countries through different organizations send consultants to develop schools with American, European and Asian knowledge, but this knowledge cannot take root because it is not indigenous to school communities. Indigenous knowledge thus, is not rooted in educational exposure to learners, incapacitating build-up of strong foundations associated with concept understanding of perspectives. So, textbook developers continue to profit from the ignorance of the populace. Ayolabi (2022) urges the Nigerian government to commit more funds in the area of research to proffer solutions to the numerous problems confronting the nation. Teachers are encouraged to embrace indigenous knowledge to solve western knowledge impediment to

bridge indigenous knowledge gap. Answers are carefully embedded in authentic researches to solve societal ills and challenges. Students' understanding of indigenous science ideas can be integrated into the tertiary curriculum to begin a build up from the kindergarten, primary and secondary schools. Copies of the current curricular for tertiary institutions should be made available to students and teachers. This will inspire great minds to discoveries that leads to local knowledge usage to solve societal problems and improve knowledge development; to appreciate and publish culturally-oriented, value laden textbooks for science knowledge. Little has been done in terms of research on this.

Paucity of Quality Science teachers for science teaching

As important as science teachers are to the development of the nation, many tertiary institutions are faced with myriads science teacher paucity. Science education is the progressive process of acquiring fundamental knowledge to advance national development. Teaching is a unique and noble profession not fully understood. Science teachers are trained, retrained and mentored to carry out assigned responsibilities of instruction, guidance, counselling and mentoring. Teachers are key factors in the implementation of the science education curriculum of any nation. Ajemba *et al*., (2021) posit that science teachers provide subject-specific instruction, create lesson plan, evaluate student performances and provide hands-on learning experiences to model and establish expected behaviour, orderliness and a disciplined classroom. Teachers are nation builders, as their teaching impact on the social, economic, political and technological advancement of the nation. Many practicing science teachers are not conversant with the subject matter content of science because they are not properly acquainted with the demands of science in their areas of specialization. They do not have the know-how to mobilize science resources to play indispensable role of initiating quality teaching to impact students' understanding of concepts. This undermines their professionalism and initiative at promoting science knowledge. Science teachers should be dynamic and be well equipped with functional, pedagogical skills to contribute effectively to developing scientifically-minded individuals who do proper investigations to acquire knowledge. Improving quality science teaching create the enabling environment for quality science learning to thrive. If every science teacher engages students differently using variety of strategies and pedagogical skills, interest could be ignited. This indicate that science teachers' professional knowledge link learning experiences to different practices in real world applications. Professional practice of science teachers enables task instruction, expertise, better task assessment that impacts professional insight. Science teachers' inability to provoke curiosity for learning diminishes potentials that would have been spurred to promote knowledge. Poor instructional presentation format due to lack of skills to promote knowledge weakens learners' ability to learn. Critical thinking is fostered with increased interest in classroom activities when multiple approaches are involved (Rogayan and Bautista, 2019). A science teacher that does not understand students' needs and intellectual potentials which are crucial for fostering students' interest may not establish healthy classroom relationship to close knowledge- deficient gap. Special emphasis is therefore, needed to address the challenge of plagiarism which hampers science education development. No tertiary institution has taken it upon itself to be interested in the training of science teachers to reposition science teaching to curb the trend, as the government is quite unwilling. Qualified science teachers are few, particularly in the rural areas where teachers

avoid to go and teach. Qualified science teachers for teaching quality science outcomes are in short supply and the nation's institutions are in dire need of them. With the huge student population intake every year into the many science disciplines, there are very few trained science teachers to effectively groom students, because, since after university graduation, have not been exposed to any form of training in emerging, engaging, skill-knowledge, deep integrated knowledge in science education.

The Way Forward

Nigeria's educational institutions need institutionalized ethical research writing culture that trains science teachers in scientific writing which must be prioritized. Pulling Nigeria's science teachers and students researchers out of this quagmire requires a firm and strategy-oriented target led by institutional reforms. The reforms must be led by example to show the ugly face of plagiarism. Practical measures should be taken to prosecute those continuing with this menace to curb the trend. It is vital that researchers possess the skill for thorough investigative work on publication. This will destroy the current compromised tendency of plagiarism and build enduring legacy for sustainable educational development. These reforms will require the rekindling of ingenuity among teachers to take ownership of their authentic work. Researchers will need to raise alarm each time colleagues try to bend the rules. Sanity and hope will be restored among academics if the thing is pursued and done. This will not come easy, but is achievable. Teachers must focus on right perspectives in writing trustworthy articles for global read by working hard to give themselves relevance and prominence in the global space for article write-ups. The new curriculum needs to capture and explore the essence of promoting indigenous knowledge to curb waste of potentials among great thinkers who are future scholars for educational development. Emerging generations will appreciate indigenous effort to effectively utilize local science knowledge with published textbooks. Teachers of science education should be taught how to write quality acceptable papers for publication and how to use different tools to check plagiarism with authenticated evidence of original publications. School management to constitute committees to adequately peruse for authentication before sending works out for publishing.

Conclusion

The paper discussed contemporary issues facing the teaching and learning of science education on publication plagiarism, foreign ideas and textbook materials imposition on students and teachers teaching and learning and paucity of science teacher quality and quality science teaching. Plagiarism is plaguing scholarly works of authentic researchers and dwindling their interest in writing. Institutions preparing science teachers for future challenges must make adequate preparation and training to help new initiates into the profession to curb the ugly trend to the barest minimum. Conducive environment should be provided for genuine researches to be carried out to decrease the prevalence of plagiarism. Academics should be helped to think-out ideas to promote scholarship. Quality production of researches should be developed among community of learners for best practice output to thrive. Tertiary institutions in Nigeria must place premium on providing good education that meets academic demands for Nigeria's educational development. This can be actualized through looking into innovative ways of providing funds for resources to minimize plagiarism and build science teachers capacity to meet educational needs for national development.

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Lecturers' Knowledge And Skills On The Integration Of E-Testing Into Learners' Assessment Processess In Polytechnics In South-East, Nigeria

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Abstract: *The aim of this study was to assess Lecturers' Knowledge and Skills on the Integration of e-testing in the Learners' Assessment Processes in the Polytechnics in Southeast States, Nigeria. The study adopted a descriptive survey design. The population of the study comprised all the Polytechnic lecturers in the South-East States, Nigeria. A sample of 960 lecturers was used for the study. The instrument used for data collection was a researcher developed questionnaire titled Assessment of Lecturers Knowledge and skill on the Integration of e-testing into the Learners' Assessment Processes of Polytechnics Rating- Scale (ALKSIELAPPRS). Data collected was analyzed using Mean, standard deviation and z-test. The results reveal that all the items (1-5) have mean scores (2.95 ≤ x ≤ 3.24) greater than the criterion mean of 2.50. With a pooled mean(x) of 3.10, it implies that to a large extent, lecturers in the polytechnics integrate into their assessment processes e-testing. This showed that lecturers in the State and Federal Polytechnics possess the knowledge and skills of integrating E-testing into the learners' assessment processes and are familiar with e-testing procedures and regulations. Based on the findings the study recommends that the Government should increase funding for the entire education sector with emphasis to ICT. This will help to improve the level of ICT facilities in the schools.*

Keywords: Knowledge, Skill, Integration, E-testing

CITATION:
Essien, J. B., Udoh, A. O. and Ekim, R. E. D. (2023). Lecturers' Knowledge and Skills on the Integration of E-Testing into Learners' Assessment Processess in Polytechnics in South-East, Nigeria. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp 251- 256

Introduction

The introduction of technology in the education sector and assessment practices has put premium on public examination results as a measure for determining standards and quality of education delivery in the Nigerian school system. Generally, the policy makers have come to believe that technology integration is worthwhile. This conviction is based on feedback gotten from candidates' performance in public examinations (Federal Ministry of Education, 2012). This assertion not only provides information about the educational progress of learners in a systematic way but also prove or an indication of teaching and learning that takes place in the classroom (FME, 2012).

Thus, in order to assure standards and quality in educational delivery in Nigeria, the Federal Ministry of Education (FME), through its relevant agencies is charge with the task to improve the reliability of national examinations in the assessment of candidates' academic performances. The ultimate objective is to deploy technology to support all aspects of assessment operations in Nigeria, from on –line

registration of candidates, computer-based administration of examination and the scoring of examination scripts, to the management of assessment feedback within and across institutions (FME, 2012). Technology integration in the classroom can support classroom instruction by creating opportunities for students to complete assignments on the computer rather than using pencil and paper (Kervin and Mantei, 2010).

Consequently, information and communication technology focused specifically on the application of new technologies in the educational context and environment, and serves as a tool for supporting the various components of education. Such components include amongst others, teaching and learning, admission and examination processes also known as learning assessment. One specific form of ICT for assessment is the computer-based test (CBT) also known as computer-based assessment or e-examination. It is a method of administering tests in which the responses are electronically recorded, assessed or both. It is commonly available for several admission tests throughout the developed countries (FME, 2012). This method of testing is important because it can measure different skills or sets of knowledge in order to provide new and better information about individual's abilities.

Owolabi (2013) study on Level of ICT skills of secondary school students and teachers and extent of their competence in its usage for instruction and assessment purposes found out students and teacher have average knowledge of ICT skills but low in their extent of usage and instruction. Adeyinka *et al*., (2018) in their work on Secondary School Teachers use of ICT and its Implications for further Development of ICT use asserts that, teachers had no knowledge of technical support and expertise in using ICT which makes their readiness and confidence of using ICT during classes very difficult. In addition, Onasanya *et al*., (2010) on Higher Institutions Lecturers' Attitude towards Integration of ICT into Teaching and Research pointed out those University lecturers acquire more skills than their colleagues in Polytechnics and colleges of education. They further added that due to inadequate training lecturers lack competence in using computer as a tool for effective teaching and research purposes.

On the other hand, the main aim of teaching and learning is to expedite the learners to display positive change in knowledge, thinking and reasoning moral and industry. The desired changes in learning activities can be realized through constructive and effective teaching and learning activities. Observation of the cognitive, affective and psychomotor changes in learner's behavior involves the process of evaluation, which has become an indispensable tool of teaching and learning processes. It is necessary to ascertain the extent to which a teacher is attaining the expected objectives of teaching either for the purpose of certification or for the purpose of improving performance. Apart from helping to improve student learning by identifying relevant remedial measures to overcome students learning problems, evaluation results are often used to grade and report students' progress to parents and guidance. It provides an essential basis to appraise the educational effectiveness of the curriculum. It therefore, becomes an important task of the teacher and those interested in sound and effective education of our youths to have a proper grasp of the basis and procedures of evaluating students learning achievement (Onasanya, 1991).

Statement of the Problem

Many factors have led to reduction of the reliability and validity of test scores. Most times, there are cases of leakages of examination questions, impersonation, bribe taking, and inefficiencies in test administration. All these tend to weaken the validity of examination and make results in institution of higher learning to be unreliable and worthless.

As these factors exist, it becomes difficult to assess candidates' performance based on the certificate they hold (Jim and Sean, 2006). These setbacks added to delay in result publication, missing scripts, manipulation of results which also compromise the quality of assessment in schools. This could also be attributed to inefficiency, lack of knowledge and skill on the part of lecturers to properly integrate e- testing into the assessment processes

On the contrary, in as much as e-testing offer new opportunities for innovation in educational assessment as it provides a potentially powerful scoring, reporting and real feedback mechanism, the pertinent question is to what extent do the institutions of higher learning integrate e-testing so as to improve the assessment processes? To what extent do lecturers have knowledge and skill for integrating e- testing into learner assessment processes?

Based on these, the study seeks to assess Lecturers' knowledge and skill on integration of e-testing in the learner assessment processes of polytechnics in south-east states of Nigeria.

Purpose of the Study

The main purpose of the study is to assess the Lecturers' knowledge and skills on the integration of e-testing into the learners' assessment processes in the polytechnics in Southeast States, Nigeria. Specifically, the study sought to:

Ascertain the level of lecturers' knowledge and skill on integration e-testing into learners' assessment processes in the polytechnics in Southeast States, Nigeria

Research Question

What is the lecturers' knowledge and skills on the integrating e-testing into learners' assessment processes in the Polytechnics in southeast States?

Hypothesis

Ho1: There is no significant difference between the mean scores of the extent of integrating e-testing into learners' assessment processes as rated by lecturers in Federal and State polytechnics ($p \leq 0.05$).

Research Methodology

This study adopted a descriptive survey design aimed at ascertaining the extent of lecturers' knowledge and skills on the integration e- testing into the learner assessment processes in the polytechnics in the south- east geopolitical zone, Nigeria. The population for the study is 3,372 which consist of 2,042 male academic staff and 1,330 female academic staff from the 6 (six) polytechnics in the southeast States, Nigeria. (Polytechnic Registry, 2022). The sample size of the study is 960 which comprise 545 male academic staff and 415 female academic staff. Stratified random sampling technique and simple random technique were employed by the researcher. The 6 (six) polytechnics were divided into strata and 4 (four) out of the 6 (six) Polytechnics were selected using simple random technique in the South-East geopolitical zone, Nigeria. These include two federal and two state owned Polytechnics. This constitutes forty percent (40%) of the total population of the four (4) selected polytechnics. The four (4) selected Polytechnics comprised 303 respondents from Federal Polytechnic, Nekede, 231 from Akanu Ibima Federal Polytechnic, 246 from Institute of Management Technology and 180 academic staff from Imo State Polytechnic, Umuagwo. The selection was done to ensure that, the sample has a representation of federal and state polytechnics in the South-east States, Nigeria. The instrument for data collection is a researcher constructed questionnaire titled "Assessment of Lecturers Knowledge and Skills on the Integration of E-testing into the Learners

Assessment Processes of Polytechnics Rating Scale" (ALKSIELAPPRS).

Results and Discussion

Result showed that; academic staff of both State and Federal Polytechnics posses' knowledge and skills of integrating e-testing into the learners' assessment processes. Result also showed that there is no significant difference between the mean scores of the extent of integrating e-testing into the assessment processes as rated by lecturers in the State and Federal Polytechnics

Research Question

To what extent do lecturers have knowledge and skill for integrating e-testing into learners' assessment processes in Polytechnics in the Southeast States, Nigeria?

The result of the analysis of data generated in respect to extent of e-testing integration are summarized and presented on Table 1.

Table 1: Mean and Standard Deviation on level of knowledge and skills of Integration of E-testing

S/N	Item (N = 960)	Σfx^{-}	$\bar{X}$	SD
1	I have attended seminars on e-testing that enable me to set questions on test, quiz and examination	3106	3.24	0.07
2	I am familiar with e-testing procedures	2830	2.95	0.08
3	I possess appropriate skills needed to conduct e-testing on test	2923	3.04	0.03
4	I have knowledge of computer which enhances my competency of e-testing.	3048	3.18	0.04
5	I can develop a website/template	2960	3.08	0.01
	Pooled Mean		**3.10**	

Table 1 contains summary of analysis of data generated in respect of extent of integration of e-testing in the learners' assessment processes of polytechnics in the Southeast States, Nigeria. The results reveal that all the items (1-5) have mean scores ($2.95 \leq x \leq 3.24$) greater than the criterion mean of 2.50. With a pooled mean (x) of 3.10, it implies that to a large extent, lecturers in the polytechnics integrate e- testing into the assessment processes.

Hypothesis One

There is no significant difference between the mean scores of the extent of integrating e-testing into assessment processes as rated by Lecturers in Federal and State polytechnics ($P \leq 0.05$).

The results of analysis of data generated in respect of differences between State and Federal polytechnic lecturers in the integration of e-testing into assessment process are summarized and presented on Table 2. Table 2 contains the summary of z-test of the significance of mean difference to explore if there is any difference in the mean response of State and Federal polytechnics lecturers in the integration of e-testing into their assessment processes. The table shows that the calculated value of z is 0.15 which is less than the table value of 1.96 at 0.05 levels of significance and 958 degree of freedom. This led to the null hypothesis being accepted. This indicates that there is no significant difference between the mean response of academic staff of State and Federal polytechnics in the level of knowledge and skill of e-testing integration into learners' assessment processes, meaning that any observed differences may be due to chance errors.

Table 2: z- Test of the Significance Mean Differences between State and Federal Polytechnics Lecturers' Rating Scores

Source of Variation	N	$\overline{x}$	SD	STD Error	df	Zcal	Ztab	Decision
State Polytechnic	426	2.96	1.01	0.066	958	0.15	1.96	Accept Ho
Fed. Polytechnic	534	295	1.03					

Discussion

The researcher discussed the findings of the study based on the research questions and hypotheses stated in the study. Result of the analysis of data show that; academic staff in the State and Federal Polytechnics possess the knowledge and skill of integrating e-testing into learners' assessment processes. The researcher also found that lecturers attend seminars and workshops on e-testing and are familiar with e-testing instructions, procedures and regulations. It was also found that many lecturers possess appropriate skill needed to conduct e-testing. The findings of this study disagree with the work of Onasanya *et al., (*2010) on higher institutions lecturers' attitude towards integration of ICT into teaching and research in Nigeria. The findings revealed that University lecturers acquire more ICT skills than their counterparts in polytechnics and colleges of education. Many lecturers lack adequate training and competence in using computer as a tool for effective teaching and research purposes.

The findings of Osang (2012) on how the adoption of electronic examination has assisted National Open University Nigeria (NOUN) also affirms with the findings of this study. The findings revealed that 81.9% of lecturers are computer literate, while 28.4% are still getting used to basic computer usage skills, which implies that most academic staff employed by NOUN are computer literate. Further analysis revealed that there is no significant difference in the mean response of State and Federal Polytechnic staff in the integration of e-testing into assessment processes. Onjewu (2013) findings on the awareness and readiness of some technical education teachers to engage technology in assessment at Kaduna polytechnic in Nigeria also disagree with the findings of this study. The findings revealed that, teachers' lack the basic computing knowledge, due to lack of awareness of the concept of technology in assessment.

Conclusion

The study assessed the integration of e-testing in the learners' assessment processes of polytechnics in South-East State, Nigeria. Based on the findings of the study, the researcher concludes that Academic staff of both State and Federal Polytechnics posses' knowledge and skills of integrating e-testing into the assessment processes.

Recommendations

1. Since lecturers in the Polytechnics possess knowledge and skills of e-testing integration, there is need for Government policy on ICTs to be fully implemented in other to enhance the performance of ICT sector as well as reinforce computer curriculum at higher level to make lecturers' and students computer literate.
2. Seminars and workshops should be organized regularly for lecturers and students to help them update their knowledge, skills, attitude and new ideas on newly developed software on e-testing.

3. Government should increase funding for the entire education sector with emphasis to ICT. This will help to improve the level of ICT facilities in the Schools.

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Problems Associated With The Administration And Supervision Of Technical Vocational Education And Training (Tvet) In Nigeria: Consideration Of Dimensional Sources

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Abstract: *This paper focuses on selected problems associated with the administration and supervision of vocational education in Nigeria. The sources of these problems include: Budgetary, Personnel, Teachers Training, Political, Cultural, on-the-job training and implementation, student enrolment and how these influence the administration and supervision of Vocational Education. Definitions of Vocational Education, the concept of administration and supervision of vocational education are discussed as well. The problems associated with administration and supervision of vocational education in Nigeria to include poor budgeting system, inadequate instructional materials, availability of personnel teachers training among others. To reduce or eliminate the problem administrators should employ problem-solving techniques as well as encourage development of salable skills in school. Government can also solve problems by increasing and implementing budget in education. It will be the responsibility of government also to solve the problem by encouraging labour-intensive method approach rather than capital-intensive and more flexible to permit the teachers apply their talents and training when necessary. A wider publicity be accorded vocational education as it is a sure way to improving its image in the eyes of the publics. As long as any form of education equips an individual for a given vocation be it medicine, engineering, law, etc. that education is vocational. Vocational education is the objective of all education and it is for everybody.*

Keywords: administration, supervision, technical vocational education and training, dimensional sources

CITATION:
Offiong, M. A. (2023). Problems Associated with the Administration and Supervision of Technical Vocational Education and Training (TVET) in Nigeria: Consideration of Dimensional Sources. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 243-250

Introduction

Technical Vocational Education and Training (TVET) is an education programme design to equip its recipients with the necessary skills that would make them self-reliance after graduation. It is expected that every graduate who passed through Technical Vocational Education and Training program should be able to create employment for themselves as there is scarcity of white-collar job in the country. Akerele in Baridam (2017) saw technical vocational education and training as that aspect of education that exposes the learner to the acquisition of demonstrable skills that could be transformed into economic benefits and sustainable livelihood. TVET could be referred to the deliberate intervention to bring

about learning which would make people more productive (or simply adequately productive) in designated areas of economic activity (e.g., economic sectors, occupational, specific work tasks) (Tretipedia,com 2017). By these definitions, it implies that vocational and technical education is the preparation of individuals to acquire practical skills as well as basic scientific knowledge which produces relevant and desirable manpower for the world of work. It also increases the number of country's workforce which are catalysts for economic and technological development of an economy. Vocational education is an integral part of general education which teaches those values, skills and knowledge which each citizen should have in order to understand the society.

FRN (2013) also conceptualized vocational education as education given in institutions as providing both scientific knowledge and practical skills required for a specific trade, employment or profession as craftsmen, technicians/technologists and scientist of similar levels in business field of engineering and applied sciences. It refers to the aspect of education which leads to the acquisition of practical and applied skills as well as basic scientific knowledge. TVET is an important skill-oriented education with the prospect of stimulating employability and national development through ensuring sustainable job creation (Inyiagu, 2014). National development involves unending process of qualitative and quantitative transformation in the capacity of a state to organize the process of production and distribution of goods and services for the material benefit of the society in a manner that sustains improvement in the well-being of its individual member in order to enhance their capacity to realize their full potentials (Sijibomi and Miller, 2014). In the light of the foregoing definitions, technical vocational education and training (TVET) is education for work, a worship-based education and education for national growth.

The Concept of Administration and Supervision

Administration is the co-ordination of human and material resources towards attainment of pre-determined objectives. It is the art of organizing and managing men and materials to attain the goals of an organization. Administration as a science employs specific steps in accomplishing its objectives, be they educational, vocational or technology-oriented. Ahiauzu (2015) sees administration and supervision as that which is concerned with the process of maintaining educational programmes from the formative stage in order to see that the objectives and goals of the programmes are successfully implemented as were planned and finding ways of correcting imbalances in the system. Akpan and Usoro (2012) stressed that vocational education administrators are concerned with the utilization of adequate resources and harmonization of relationships and interactions in a suitable environment for attainment of goals of vocational education programmes. As posited by Ubulom (2004) administrators and supervisors in vocational education are professional persons who direct, stimulate and encourage vocational activities for the purpose of attaining the ultimate in administrative practice and quality of learning. Ubulom also opined that administrators and supervisors are individuals who have acquired the essential competencies involved in the administration and supervision of vocational education for manpower development suitable for the world of work.

Supervision is the act of getting something done and also a quality-oriented activity. It is an element in the administrative process which stimulates, directs and controls workers and their efforts (Mbipom, 2007). In educational process, supervision is capital intensive

because it requires human and material resources in order to effectively play its role. Some of the roles of vocational education supervision include ability to get along with and direct people, adequate educational preparations, creating a conducive climate for improving instruction and ability to communicate. Supervision may also be perceived as a way of improving and over-seeing certain groups with the hope of seeking their co-operation in order for the supervisor to be successful in their task of supervision.

Problems Associated with the Administration and Supervision of Vocational Education

Vocational education system lacks effective supervisors and administrators for proper implementation of vocational education objectives. This adequacy obviously contributes to the poor quality of programming product for the modern labour market. Akpan (2001) has observed that vocational education programmes are influenced by complex and changing social, economic and demographic factors individually and collectively. These factors affect the purposes and contents of vocational education courses and programmes, enrolment, teaching methods and material guidance, budget, staffing, equipment and supplies. Effective vocational education administration and supervision at any level, local, state, or national must cope with these forces as they change, keeping a particular eye on those which have the greatest significance for their level of responsibility. Some of these factors and their effects on vocational education administration and supervision are rather obvious while others are more subtle.

These problems are as follows: Inadequate budget system, Inadequate instructional materials and Inadequate number of instructional personnel.

a)Unstable school calendar

- Failure to integrate vocational education into the Nigerian culture
- Errors in policy formulation and implementation
- Ineffective on the job training
- Poor students' enrolment

Inadequate Budget System

Inadequate funds budgeted for Technical Vocational Education and Training (TVET) is a serious impediment against attainment of the effective programme. A good Technical Vocational Education and Training (TVET) programming should have proper budget and effective funding. The recession that started in 2007 took a serious toll on school financing across the country as education budgets is increasing being cut into geometrically and progressively (Park, 2011). Adequate funding is required for the purchase and maintenance of teaching and learning materials and equipment at the right time. Funds are also needed for good placement of teachers' trainees in good work experience programmes for regular administration and supervision or research and learning materials development. The stipend for students undergoing Students' Industrial Work Experience Scheme (SIWES) should also be paid regularly. A programme that is starved of funds skills the ingenuity and motivation of teacher-trainers and leads to the production of half-baked program graduates. Against the above background in this discourse, what can Technical Vocational Education and Training (TVET) achieve when its share of national budget of 26% for education as a whole is unknown or not specified. 26% of the National budget is given to education without specifying the proportion that belongs to Technical Vocational Education and Training (TVET). Inadequate financial budget as a source of problem in Technical Vocational Education and Training (TVET) at this juncture needs explanation.

b) Inadequate Instructional Materials

The materials available for the administration and supervision of Technical Vocational

Education and Training (TVET) are grossly inadequate and in most instance not available. This situation counters the effort towards achieving effectiveness of the programme. To teach Technical Vocational Education and Training (TVET) effectively, there must be adequate provision of facilities in terms of space, equipment and materials to ensure attainment of quality education in vocational and technical education. The training environment should be like the work environment as Prosser principle emphasizes. Teaching with real objects, in real situations can help to facilitate the work skills demanded by employers of labour. However, it is noteworthy that the absence of real instructional objects and teaching situations are potential creators of problems against effective implementation of Technical Vocational Education and Training (TVET) for manpower production.

c) Inadequate Number of Instructional Personnel

The Federal Republic of Nigeria in its national policy on education (FRN, 2013) holds the view that no educational system can be better than teachers who run and operate it. This is true of Technical Vocational Education and Training (TVET) because it is a life-sustaining education. the importance of Technical Vocational Education and Training (TVET) in national development as well as its high cost is the major reason why those who are charged with the delivery of the programme must be highly skilled and proficient in the discharge of their various roles. These roles include directing learning, meditating the culture, counseling and guiding students, liaising between the school and the community, curriculum planning and development. Associated with the above reasoning is the problem of securing the right culture of the desired educators which unfortunately are in short supply. There is a brain-drain of workers in TVET to industries and other jobs. The dearth of qualified and experience teachers in most of the technical colleges in Nigeria is one of the major challenges of Vocational and Technical Education development. Ayonmike, Okwelle & Okeke (2015) found that some of the challenges facing Vocational and Technical Education in Nigeria are poor teaching methods employed by teachers, teachers' lack of interest to teach, poor research attitude of teachers, poor preparation of lesson by teachers among others. This has affected the production of qualified Vocational and Technical Education teachers. The result of this is shortage of qualified teachers to handle these subjects/trades in Technical Colleges thereby producing half-baked graduates. The school management in order to fill the gap makes use of unqualified teachers. Its consequences is the graduation of untrained and unqualified graduates of Vocational and Technical Education programme who are jobseekers instead of self-employed and job creators.

2. d.) Unstable School Calender

The frequent change of government usually brings about change of government policies regarding human endeavors including education. In Nigeria, it is a common experience that the successive administration may not want to implement the policies and programmes of the previous administration. This singular act usually affects effective administration and supervision of the school's system. Unstable academic calendar is also caused by the various trade union groups within the schools. They often embarked on strike action due to disagreement with the government on welfare issues. Ogunode (2020) established that half bake graduates, poor coverage of syllabus, resources wastage, students' involvement in criminal activities and students prolonged years of graduation are the effects of unstable academic calendar. In other words, inconsistent policies on how instruction in schools should be supervised and the

categories of people to be involved in the activity would adversely pose an offensive challenge to instructional supervision especially in secondary schools and technical colleges in Nigeria. A politically stable nation is a progressive nation. Politically instability of a nation is undesirable because it generates problems which may take time and megabucks to solve.

e) Failure to Integrate Technical Vocational Education and Training (TVET) into Nigerian Culture

Even though the National policy on education has laid emphasis on functional education for all citizens of Nigeria at all levels (FRN, 2013), the requirements for a solid foundation towards proper development of the desired goals are not hitch-free to the extent that Nigeria imparts a preponderant portion of tools, materials and equipment. It needs for its development, associated problem must be expected. Dependence on resources imported from outside for Nigeria's development roles it of its confidence in self-growth. Making TVET part of Nigeria's culture is apparently the solution for its development problems (Okoro, 2000). The history of technological development is an aspect of culture.

Furthermore, cultural diversity has been observed to pose problem for TVET in its administration and supervision. There are three notable cultural diversities in Nigeria, which apparently are associated with the implementation of Nigeria as a nation. These cultures are:

(i) Western culture which gave rise to Christian education practiced in the south for over one hundred years.

(ii) Islamic culture which is based on Islamic religious faith. Islamic had been observed to equate with Islamic education which for long time created a gap between western and Islamic systems of education.

(iii) Normadic culture is that in which many northerners' resorts to normadic lifestyle. Within this culture, it has been difficult to accept western form of Christian education which favours the establishment and development of TVET in Nigeria.

When it comes to basing the development of Nigeria on the educational contributions by the three cultures one is bound to observe the problem of even development in every corner of the nation. Here lies the detrimental effect of cultural diversity on National development via TVET instrumentation.

f) F) Ineffective On-The-Job Training

On-the-job training has been successfully employed by the advanced nations to improve the skills of their work force. Their success in utilizing on-the-job training to meet the demands of an expert personnel to do the job. Their success also depends on their collaboration between school and industry. When emerging technologies create new skills, knowledge and related work attitude, there is always a corresponding need to retrain workers on the job to assist them cope with new work demands. Where on-the-job training programme is ineffective or absent technical vocational education and training is faced with problems which are likely to hinder progress in various dimensions to the disfavor of national development. As proposed by Jacobs (2014), training can be considered from a number of different perspectives. It can focus on different types of content, primarily categorized as managerial, technical, and awareness, among other types. It can be delivered using an array of training approaches, methods, and media, depending on the situation. It entails either short or long-term updating of employer/teachers' knowledge and skills through sandwich courses or further studies.

Currently, many TVET teachers enjoy on-the-job training in the Nigerian/African as well as third world universities, institutions of

governments and agent of quality education (NCCE, NUC, NBTE, etc) are also involved in aiding teachers to improve their skills. TVET teachers need to attend seminars, workshop and conference in order to update their professional skills for classroom/workshop practice. While seminars and conference may be largely theoretical in orientation, workshops are usually practical intent. Most often, a better organized conference may include units of seminars, workshops, lectures and demonstrations. While on-the-job training is very crucial and welcome, it can also constitute a source of problem. Absence of staff on training may lead to shortage of workers and their training may involve megabucks.

g) Errors in Policy Formation and Implementation

Poor policy formulation has influences on the functionality of TVET despite the rapidly expanded writing on TVET. There is at present little agreement on the dimension of scope of education planning. Implementation of TVET planning is a process of preparing information in the form of an alternative (with estimates of their specific consequences) to aid decision making for management policy formation and administrative action. A nation that promotes TVET ability of its citizen to qualify for and hold productive employability and job mobility of graduates encourages individual to respect the dignity of labour and develop the feeling that work both necessary and satisfying (Akpan, 2001), that this assertion feasible and cherishable are non-existent in the system.

h) Poor Students' Enrolment

There is negative perception from the society that TVET is for the "drop out", in schools. There is general attitude found "quick wealth of get-rich quick syndrome".

A major factor as earlier stated in relation to operating TVET Programme is called the "image" of TVET situations are bound where well-equipped labour oriented and well-taught courses are abandoned because no student is available. There exist situations where parents, students, teachers and often the public look down upon TVET as education for "second class" citizen. Instances are common where guidance and counselors are reluctant in advising students with above-average aptitudes to go into TVET programmes. It may be shocking to observe that even frontline advocators for TVET programmes including TVET educators, find ot extremely difficult to allow their own children opt for TVET programme.

At this point, it becomes necessary to draw our attention to the fact that poor image of TVET has serious effect on student's enrolment and administrative pattern of the programme. Orientation programmes should be carried out towards enlightening the general public on the need for their children to be TVET oriented in light of the prevailing meltdown.

The Way Forward

The Buhari's administration is currently deliberately reshaping the terrain of TVET for better performance. In view of the problems besetting the realization of the goals of TVET, a national seminar was held in November, 2000 in collaboration with UNESCO. The goals of the seminar were to re-engineer and reposition TVET for better performance in the 21st century and to market prescribed reforms to stakeholders. The material outcome of the seminar was the preparation of a national master plan for the development of TVET in the 21st century. Key ideas in the national master plan include the institution of entrepreneurial education at all levels, raising the quality of TVET teachers, incentive, and marketing of TVET and improving the managerial capacity of the subsector.

Some modest achievements in the last few years include rehabilitations and expansion of facilities, curriculum revision and teaching capacity building in collaboration with UNESCO.

Increased flexibility in the system enables in the hitherto excluded products of technical colleges to gain admission more easily into tertiary institutions. There is gradual change of social attitudes toward TVET and a focusing of government attention on their development. There is also a growing recognition of the importance of TVET for the success of democracy, attainment of mass employment and national economic development.

Technical Vocational Education Training (TVET)

With a scheme of financial empowerment of the clientele is new government's main approach to poverty eradication. National Agency for Poverty Eradication as a parastatal of the Federal Government for poverty eradication, spearheads the idea of the use of TVET with financial empowerment of the clientele to eradicate poverty.

In 2002, the Federal Government took a further step to reposition TVET for greater achievement in the national growth. Major policy innovations in this regard include:

i. The reversal of federal technical college craft programmes to full secondary education duration of six (6) year. Pupils from primary schools are admitted into the junior college component of technical colleges to enable the technical colleges stand a fair chance of having good quality entrant as well as provide an early orientation of the students toward TVET and the world of work. In addition, the Federal Ministry of Education (FME) has converted its technical colleges to science and ordinary craft and programmes at senior secondary level to attract entrants.

ii. Setting up an action plan following the resolution of higher Education Submit of 2002 to review the policy and mandate of polytechnics and colleges of education to enable them award degrees. Government is therefore considering the adoption of a policy of separate development and independent operation of tertiary institutions. The policy of separate development is geared towards eliminating all forms of marginalization consequent upon the old tradition.

iii. Setting up an action plan to review the ceiling in career progression of graduates and staff of polytechnics and colleges of education so that the historical disparities between university and polytechnic graduates may be eliminated.

iv. Setting up plans to integrate entrepreneurial education into the scheme of technology education.

v. Introduction of post-HND programmes to enable holders of HND to qualify for professional registration and practice.

For the future efforts of the government will focus on full implementation of the national master plan on TVET particularly the attainment of the decade goals. Also, efforts will be focused on the attainment of the decade goals. Also, efforts will be focused on the implementation of the national action plan on the resolutions of the 2002 National submission of higher education. for this purpose, there would be the need to create a National Advisory Council on TVET comprising a group of professionally-competent educators who are versed in the fields and could galvanize a sense of mission to drive TVET to meet national expectations. The logic of this approach is to involve stakeholders of innovations in the process of implementation.

Recommendations

Sequel to the foregoing discourse, the following recommendations are proffered:

- The federal, state and local government should assist in the development of TVET in schools and colleges.
- Technical Vocational Education and Training teachers should be given on the job training which will enable them update their teaching skills.

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Integrated Science Curriculum: Features, Problems and Prospects

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Abstract: *Nigerian Educational System has gone through various developments and changes viz a viz curriculum issues. This paper reviews the genesis of integrated science curriculum development in Nigeria to ascertain its present status. It highlights the structure and content of Integrated Science Curriculum from 1970 till date. It identifies the problems associated with Integrated Science Curriculum implementation to be teacher related, administration – related, students – related and parents – related. The prospects of Integrated Science Curriculum are discussed and useful recommendations are proffered.*

Keywords: Nigerian Science Education Curriculum, STAN Integrated Science Course, Basic science, Basic Science and Technology; Challenges, Prospects

CITATION:
Usendia, A. U. (2023). Integrated Science Curriculum: Features, Problems and Prospects. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 234-242

Introduction

The term curriculum has been defined by many people in many places. It is a vehicle through which education is attained (Offorma, 2005). It is the sum total of all experiences through activities and experimentation which the learner is provided with or acquires at schools. In sciences, the activities and experiences offered to the students come from the classroom, the laboratory, science fairs, quizzes, club activities, field trips, educational workshops, conferences, seminars, assignments, etc. All these, help to achieve the pupils' objectives of education in general and science education in particular. The steps involved in the curriculum process are statement of objectives, selection of learning experiences, selection of content, organization and integration of learning experiences and contents, and evaluation.

Origin of Science Education Curriculum In Nigeria

According to Igwe (2003), science first appeared in the Nigeria curriculum in 1859 when the Church Missionary Society (CMS) Grammar School in Lagos introduced a rudiment of nature study, described by Bajah (1983) as the learning of the environment and hygiene. Other schools like Saint Gregory's College (Lagos), Hope Waddel Institute Calabar and Baptist Training College (Ogbomoso) followed later in teaching nature study. By this time, the rural science syllabus/Curriculum was formulated for Science teaching at the primary schools. Other biology related subjects were introduced such as botany, physiology and agriculture at the secondary school level (Akani, 2011).

The enthusiasm for nature study did not last long and by 1920 it had lost its impetus and

many teachers had begun to express dissatisfaction. Following the recommendation of an African education Commission sponsored by Phelps Stokes fund of America to tour the British West African colonies, the teaching of science began in full swing and "general science" was introduced which was a coordinated survey of physics, chemistry and biology. Shortly after 1950, science had graduated from being taught as general to separate sciences of physics, chemistry and biology (Igwe, 2003).

Introduction of Integrated Science Curriculum in Nigeria

Bajah (1983) describes how in 1968, a request was received by the Science Teachers Assosiation of Nigeria (STAN) from the West African Examination Council (WAEC) to make recommendations for revision and improvement of the then West African School Certificate (WASC) science syllabus due to modern developments in science education. Another reason for updating the syllabus was to bridge the gap between WASC and Higher School Certificate (HSC).

STAN constituted three curriculum developments committees, one each in Biology, Physics and Chemistry in May 1968. A fourth committee was also constituted in Mathematics later that year. The committees received assistance from Ford Foundations, Curriculum Renewal and Educational Scientific and Cultural Organization (UNESCO) and Longman Nigeria Publishers (Aniodoh, 2012).

In one of their meetings, a member wanted to know the foundation on which the new WASC syllabuses were to be built. This question generated a lot of controversy. Some members opted for an already existing program fot the Junior forms of secondary schools – the Aiyetoro Basic Science program supported by the Ford Foundation through WASC. Others said a new program should be developed by STAN. After a series of brainstorming, it was agreed that STAN could develop an integrated science program if it so wished while the original support for syllabus renewal by Ford Foundation through WASC continues. The Nigerian Integrated Science project was given birth to and a new committee with representatives from the various subject committees formed the integrated science curriculum committee. In 1970, the STAN Curriculum Development Newsletter No.1, which contained the statement of Philosophy, Methodology, content and evaluation was published.

According to Aniodoh (2012), the first ever Integrated Science textbook in Nigeria appeared towards the end of 1970. It was written by three Secondary School Science teachers and published by Oxford University Press (OUP) Nigeria. Each set was made of Pupils workbook and Teachers Guide.

In 1971, STAN published the Nigerian Integrated Science Project (NISP). They were in two volumes, each volume consisting of pupils' workbooks. The publishers were Heinemann Educational Books, Nigeria. In 1973 and 1976, Macmillan Publishers Nigeria Limited and Longman Nigeria Limited respectively published their own versions of Integrated Science textbooks. All Integrated Science textbooks closely followed the guidelines in the STAN curriculum development newsletter No.1 (Aniodoh, 2012).

Objectives of STAN Integrated Science Course: The STAN Integrated Science course was expected to help pupils to: i) Be actively involved in the learning process ii) Develop the motivation and ability to work and think in an independent fashion iii) recall information and experiences iv) devise schemes for solving problems v) use and classify a given information vi) apply previous knowledge to new situations vii) Interpret information showing evidence of judgment and assessment viii) Communicate selectively and effectively ix) Relate their

experiences in each subject area to other subject areas and to live in his society.

Process Skills Adopted: The above modes of behavior were to involve the pupils in acquisition of a series of skills including:

- Observing carefully and thoroughly.
- Reporting completely and accurately what is observed.
- Organizing information acquired by the above processes.
- Generalizing on the basis of acquired information. Prediction as a result of these generalizations.
- Designing experiments (including controls where necessary) to check these predictions.
- Using models to explain phenomena where appropriate and
- Continuing the process of inquiry when new data do not confirm to predictions. (STAN, 1970).

Content Of Stan Integrated Science Course

The course content specification contained six sections broken into seventeen units for two years, eight units in year one and nine units in year two. The sections and units are shown below:

Year 1

Section 1 Exploring Science – Variety in Matter

Unit 1 Observing the environment
Unit 2 Order in matter 1 (living matter)
Unit 3 Order in matter 2 (non – living matter)
Unit 4 Materials and where they come from

Section 2 An Investigation of Air and Water

Unit 5 The nature of air and the problem of burning
Unit 6 Water – what is water made of?

Section 3 Force, Work and Energy

Unit 7 Force and Work
Unit 8 Forms of energy

Year 2

Section 4 Activities of Living Things

Unit 9 Movement
Unit 10 Feeding
Unit 11 Reproduction, Development and Growth

Section 5 Another Look At Energy

Unit 12 Energy: Conversions and transfer
Unit 13 Nutrition and diet in man
Unit 14 Energy and chemical systems

Section 6 Life and Environment

Unit 15 Health and disease
Unit 16 Mineral resources of the earth
Unit 17 Man in space

Integrated Science Under The 6-3-3-4 System Of Education

Following the adoption of a new National policy on Education advocating a two – tier 3-3 system of secondary education, there was an urgent need to design a core content curriculum on various subjects for the two levels of secondary education. The core curriculum for the junior secondary school integrated science was one of such attempts by the Federal Ministry of Education to implement this national policy. The core curriculum emerged following the revision, reorganization, updating and expansion of the old two – year integrated science curriculum to the new three – year junior secondary school programme,

The objective, process skills, teaching approach and evaluation method for its implementation remained the same as those published in STAN curriculum Newsletter No. 1.

The thematic approach was adopted for its content and its intended learning were set out under six themes (FME 1985), these include:

Theme 1: You as a living thing
Theme 2: You and your Home
Theme 3: Living Components of the Environment
Theme 4: Non – living Components of the Environment
Theme 5: Saving Your Energy
Theme 6: Controlling the Environment

Each theme featured throughout the three years. The topics built up progressively with increasing difficulty the spiral or concentric curriculum.

The published material for the implementation of the JSS Integrated science core curriculum included the printed curriculum, new editions of text in the three volumes for years 1-3 consisting of pupil text, pupil's workbook and teachers guide. Publications by STAN with Heinemann, Longman, UPL and Macmillan, were made available for use.

Integrated science also started with the 6-3-3-4 system of education in Nigerian primary schools. It also adopted for the Teacher Education in the colleges of Education and Universities. It is very prominent in the curriculum of the National Teacher Institute (N.T.I).

The objectives and contents of the six themes of the core curriculum Integrated Science for Junior Secondary Schools

Theme 1: You as a Living Thing

The main objective of this theme was to encourage the pupil to develop awareness that he/she is of the living world. Specifically, the theme focused on the biological characteristics and attributes that are associated with life.

Theme 2: You and Your Home

Pupils constantly interact with biological and physical components of science in their homes. This theme focused on these interactions and the parts the pupil can play with a view to giving the child a deeper and clearer understanding of science in the home.

Theme 3: Living Components of the Environment

We share this world with other living things with whom we interact biologically and physically. The aim of this theme was to encourage the pupil to develop an awareness of what we have in common with these other living things and how we interact with them.

Theme 4: Non – Living Components of the Environment

Within the environment, non – living things exist and we constantly interact with them in our daily activities. In this theme, the physical and chemical change that take place and the energy changes that occur were discussed.

Theme 5: Saving Your Energy:

Fundamentally, all human activities depend on energy. Conservation of energy should therefore be one of our priorities. Science has made a great contribution towards the saving of energy. This theme thus discussed in genera the concept of energy and energy – saving devices that have been invented by scientists to aid human activities at home and at work.

Theme 6: Controlling the Environment

Primarily, because of his intelligence, man has a great influence on his biological and physical environment. The aim of this theme was to draw attention to this influence and to teach the pupils how to maintain a good environment through proper controls.

Integrated Science Under The 9-Year Basic Education

In line with government declaration for a 9 – year Basic Education Programme, the NERDC was directed by the National Council on Education (NCE) to re – structure and re – align the existing primary and junior secondary school curricula to meet the targets of the 9 – year Basic Education in the context of National Economic Empowerment and Development Strategies (NEEDS) and the Millennium Development Goals (MDGs). The NCE also approved a new curriculum structure namely: Lower Basic Education Curriculum (primaries 1 – 3), Middle Basic Education Curriculum (primary 4 – 6) and Upper Basic Education Curriculum (JSS1 – 3) listing relevant subjects for each level (FME, 2007).

Between January and March 2006, the NERDC convened a meeting of experts and also

organized several workshops to produce the 9 – Year Basic Education Curriculum, which would ensure continuity and flow of themes, topics and experiences from primary school to junior secondary school levels. The curriculum reflected depth, appropriateness and inter – relatedness of the curricula contents. It was a 9 – Year curriculum taking care of science and technology for primary, and science for the junior secondary schools.

This 9 – Year Basic Science Curriculum was the production of a re – alignment and restructuring of the revised curricula for Primary Science and Junior Secondary Schools Integrated Science. In selecting the contents, three major issues shaping the development of nations worldwide, and influencing the world of knowledge today were identified. These were globalization, information/ communication technology and entrepreneurship education. The desire of Nigeria to be identified with contemporary development worldwide, called for the infusion of relevant contents of four Non – school curriculum innovations in the areas of Environmental Education (EE), Drug Abuse Education (DAE). Population and Family Life Education (POP/FLE) and Sexually Transmitted infection (STI), including HIV/AIDS.

Infusion of content occurred in every class from Basic 1 – 9. Also some introductory technology topics were introduced at the lower and middle levels, while leaving the upper with purely science topics. The overall objectives of this curriculum were to enable learners to:

1. Develop interest in science and technology.
2. Acquire basic knowledge and skills in science and technology.
3. Apply their scientific and technological knowledge and skills to meet societal needs.
4. Take advantage of the numerous career opportunities offered by science and technology.
5. Become prepared for further studies in science and technology.

In order to achieve a holistic presentation of science and technology contents to learners, the thematic approach to content organization was adopted. Consequently, four themes were used to cover knowledge, skills and attitudinal requirements. These were: You and Environment, Living and Non – Living Things, You and Technology and You and Energy

At the upper basic level however, theme 3 "You and Technology" was changed to "Science and Development". The topics under each theme were sequenced in a spiral form beginning with the simple to the complex across the 9 (nine) years of Basic Education in order to sustain the interest of learners and promote meaningful learning. The use of guided inquiry method of teaching and learning was implied in the activities prescribed under each topic in order to promote learning by doing and skills development.

The theme "Science and Development" was added to expose students to developments in science and technology alongside skills that will enable them to face challenges, make informed decisions, develop survival strategies, and learn to live effectively within the global community. The teacher is the key factor in the provision of quality education. Therefore, for the effective implementation of this curriculum, capacity building of the teacher was to be ensured on a continuing basis.

The aspect of the curriculum for primary school (lower and middle basic) was referred to as Basic Science and Technology while that of the junior secondary (upper basic) was referred to as Basic Science.

Integrated Science Curriculum (Revised, 2012)

This curriculum is known as the Basic Science and Technology Curriculum. It is a product of the restructuring and integration of four Primary and Junior Secondary School (JSS) science curricula namely Basic Science, Basic

Technology, Physical and Health Education, Computer Studies/Information Communication Technology (ICT). The integration of these science curricula became necessary for the following reasons: a) Recommendations of the Presidential Summit on Education in 2012 to reduce the number of subjects offered in Primary and Junior Secondary Schools; b) Feedback from the implementation of the curricula in schools that identified repetition and duplication of concepts as the major cause of curriculum loaded c) Need to encourage innovative teaching and learning approached and techniques that promote creativity and critical thinking in learners, d) need to promote the holistic view of science at the Basic Education level for better understanding of contemporary and changing world; e) need to infuse emergent issues that are of national and global concern such as gender sensitivity, globalization and entrepreneurship.

The objectives of Basic Science and Technology Curriculum

The Basic Science and Technology Curriculum (Revised, 2012) is expected to enable the learners:

- Develop interest in science and technology
- Acquire basic knowledge and skills in science and technology
- Apply scientific and technological knowledge and skills to meet contemporary societal needs
- Take advantage of the numerous career opportunities provided by science and technology
- Become prepared for further studies in science and technology
- Avoid drug abuse and related vices, and
- Be safety and security conscious (FME, 2012).

Structure of the Basic Science and Technology (BST) Curriculum

The thematic approach to content organization is adopted in order to achieve a holistic presentation of scientific and technological concepts and skills to learners. The Themes and Sub – Themes that formed the integrating threads for the Basic Science and Technology Curriculum are shown in the Table 1. Themes and sub – themes of BST curriculum. The sub themes for each year in the Junior Secondary School is further broken down into topics for the three years.

Description of Basic Science and Technology Curriculum

The Basic Science and Technology Curriculum is variously described as i) Core curriculum ii) Spiral curriculum iii) Activity based iv) Learner based v) non disciplinary or anti disciplinary curriculum

Mode of presentation

The National presentation format is adopted. Each theme is treated under the following components: i) Topic ii) Performance objectives iii) Contents iv) activities (teacher and students) v) Teaching and learning materials vi) Evaluation guide.

Challenges of Curriculum Implementation in Nigeria

The curriculum is usually planned and developed by specified authorized agencies and handed down to the schools for implementation. The responsibility and task of implementing the school curriculum lies with the classroom teacher (Etuk, Udosen, Emah, Edem and Afangideh, 2015). First it is the task of the teacher to interprete the inert curriculum in order that it could be understood by the teacher as well as the learner. According to Obioma (2014), this involves correctly establishing the scope in terms of coverage breadth and complexity of intellectual demand of the content or subject matter. It is also the

responsibility of the teacher to translate the board goals into behavioral objectives, arrange and organize the content for continuity, sequence and interpretation, select and set up appropriate learning activities for the learners, direct and monitor the learning process, select and apply the teaching aids, resources and materials to determine the learners' achievements and performances (Kelly, 2009) even though the teacher is the key factor.

Table 1. Themes and sub – themes of BST curriculum

THEME	PRIMARY	JSS
	SUB-THEME	SUB-THEME
BASIC SCIENCE	Exploring our Environment Living and Non-living Things	Learning About our Environment You and Energy Science and Development
BASIC TECHNOLOGY	Understanding Basic Technology You and Energy	Understanding Basic Technology Material and processing Drawing practice Tools, Machine and processes Safety
PHYSICAL AND HEALTH EDUCATION	Fundamental Movements Basic movements Athletics Games and Sports Health Education Pathogens, Diseases and Prevention Drug Education Responsible Parenthood	Basic Human Movement Sports and Game Health Education Moving our Body Part Athletics Contact and Non-contact Games
INFORMATION TECHNOLOGY (IT)	Basic computer operations and concept Basic concepts of Information and Technology	Basic Computer operations and concepts Computer Application Packages Basic Knowledge of Information Technology.

In the Nigerian school system, the process of curriculum implementation is beset by many other challenges based on administration, students and even the parents.
These challenges include:

Teacher Factors Such as: i) Quality of Teachers for Integrated Science Program ii) Quantity of Qualified Integrated Science Teachers iii) Teaching method Teachers Attitude to Work

Administrative Challenges Examples of such policies are; i) frequency of review of Integrated Science curriculum ii) Inadequate funding of schools iii) free and compulsory Education iv) school Monitoring a) Inadequate provision for In – service Programme b) Non – Availability of Integrated Science Curriculum c) Discipline d) Delegation of Duties d) Problem of qualified Guidance and counseling Personnel in School.

Student Related Factors; Lack of Interest, Indiscipline, socio – economic status of parents

Other Challenges Include; Inadequate instructional materials, overcrowded time table; the content of Integrated Science, curriculum fear of hazards, stressful planning and organization, information and communication and technology (ICT).

Prospects Of Integrated Science Curriculum

According to Balogun (1978), there are four reasons in support of science integration. These are philosophical, psychological, pedagogical and practical consideration. The philosophical consideration is borne by the fact that although bits of the world can be learned at a time, the ultimate aim of doing science is to provide a unifying view of the world. Psychologically, it takes cognizance of Burner's view on readiness. Pedagogically, it conforms to a number of pedagogical principles – beginning with the whole before its parts, providing an overview detail. Practically, science integration makes for effective use of available teachers and teaching facilities especially where there is shortage of good teachers and facilities. It eases the pressure of time table overload. The prospects associated with integrated science education are numerous. An integrated science course that cuts across the educational levels will help to provide the needed.

- Science for all citizen internationally;
- Interaction of science and society worldwide;
- Requirements for further education in fields other than the sciences;
- Flexibility in the training for the world or work;
- Ease in curriculum development and
- Easy and reliable evaluation

There is a general need for less specialization and the presentation of wider views of science which integrated science can provide (Gbamajah, 1991). Integrated Science courses are now developed for the higher secondary and tertiary levels of education and to provide for a "Science for all" programme for those not offering single science courses.

Integrated Science forms part of the General Studies course for non–science degree students in Nigerian Universities. Also in Nigeria, integrated science is now offered in all the Colleges of Education for the award of the Nigerian Certificate in Education (NCE). Many Nigerian Universities also offer Integrated Science for the award of the B. Sc. (ED) degree or the B(Ed) in Teacher Education or Science Education Programme. Universities offering these programmes are listed in UME Brochure on Guidelines for Admissions into Nigerian Universities (JAMB, 2014).

Many tertiary institutions now introduce courses of inter – disciplinary or integrated nature to provide for wider background is science. Such programme like biochemistry, microbiology, geo – physics or applied chemistry tend to attract more entrants than the single discipline courses like chemistry, physics or biology.

The 6-3-3-4 system of education in Nigeria and the integrated science enterprise are said to be closely related. According to (Gbamajah, 1991), the philosophy and objectives of the 6-3-3-4 system of education are very much in line with the philosophy, objectives, and methodology of integrated science. It helps students to demonstrate understanding, application, ans interpretation of scientific knowledge through direct experience. The 6-3-3-4 system of education in Nigeria will be made more functional if science of an integrated nature is taught in the curriculum at all levels.

Conclusion and Recommendations

The integrated science curriculum is an essential tool for societal development through science and technology. For proper implementation of this curriculum, the following recommendations have been made among others.

1. Vocational courses should be mounted for integrated science teachers presently engaged in teaching the subject to improve the performance.
2. The educational stakeholders should make funds available to sponsor integrated science teachers to workshops and conferences. These in – service courses

should be considered during promotion exercises.

3. Funds should be provided for infrastructural developments such as functional laboratory, ICT facilities and even classroom blocks.
4. Curricula should be supplied to schools and its implementation should be properly monitored by school administrators.
5. Integrated science departments should be set up as fully-fledged department in our Colleges of Education and universities for proper training of Integrated Science teachers to improve on the number and quality.
6. The students should be motivated by their parents and teachers to develop interest in integrated science.
7. The parents should as much as possible, be concerned about their wards progress in school. They should provide for them and also monitor their progress. They should also help in providing teaching resources through Parents Teachers Association (PTA).
8. In the absence of a well-equipped laboratory, teachers should improvise from locally available materials.
9. Teachers should develop a healthy attitude to work. To encourage this, they should be given incentives for hard work. This will motivate them to improve their performances.

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Spatial And Seasonal Variations In The Fish Species Composition In Essene Creek, Ikot Abasi Lga, Southern Nigeria

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Abstract: *A twelve months (April 2021 to March 2022) investigation was carried out to determine the ecology of fish species in a mangrove ecosystem of Essene Creek location in Ikot Abasi, Akwa Ibom State, southern Nigeria using standard sampling and Laboratory procedures. Results revealed that a total of 123 specimens were collected during the study period, which comprised of 37 species, 29 genera, 21 families and fish 9 orders. The percentage abundance in terms of number of individuals of fish species sampled in the three sampling station stations showed a steadily progressive increase downstream as follows: 18 individuals (14.63%), 20 individuals (16.26%) and 85 individuals (69.11%) for stations 1, 2 and 3 respectively. Out of the 9 fish orders sampled, the least number of specie/specimen was observed in the Carangiformes, Elopiformes, Mugiliformes, Osteoglossiformes, and Polypteriformes (1 specie; 0.81%; 1 specimen) while the highest number was obtained in Perciformes (20 species; 70 specimens; 56.91%). In terms of family abundance, Cichlidae had the highest (10 species; 27.02%, 43 specimens; 34.95%) whereas the lowest was obtained in Carangidae, Elopidae, Mugilidae, Notopteridae, Polypteridae (1 specie; 2.70%, 1 specimen). Only eleven species made significant whereas twenty-six species had insignificant contributions; with the most significant contributor being H. fasciatus (70.07%) based on Index of Preponderance. Ichthyofaunal abundance and diversity were higher in the wet season (86 specimens; 69.92%) than in the dry season (37 specimens; 30.08%). However, with appropriate management and conservative measures here proposed, the important economic and endemic fishery of Essene Creek can be developed and sustained maximally.*

Keywords: ichthyofaunal composition, Essene Creek, spatial and seasonal, Index of Preponderance, abundance

CITATION:

Dodeye, E. O., Ekpo, I. E., Umoh, E. M., Udo, M. T. and Joel, D. V. (2023). Spatial and Seasonal Variations in the Fish Species Composition in Essene Creek, Ikot Abasi LGA, Southern Nigeria. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp.224- 233

Introduction

Species composition is an indicator of the habitat of a particular fish species in a certain aquatic environment. It could consist of the vertical composition or the horizontal composition (Martin and Okadi, 2009). The total brackish area is estimated as 12, 940 km^2 with mangrove Comprising 9700 km^2 and the saline swamps of the Niger Delta occupying 750,000 hectares. The Coastal area is enriched with abundant aquatic resources such as lagoons, creeks, deltaic distributaries, floodplains, mangrove swamps, etc. Most of these Coastal and near shore resources are important for artisanal and commercial fisheries,

transportation and recreational purpose Ekpo and Effanga (2018). Species diversity and abundance are affected by various factors such as heavy harvest, anthropogenic influences, destruction of habitat, as well as. Fishes show great diversity in size, shape, color, morphology, physiology and in the habitat, they adapt to. Fishes are mobile and the resident community in any area may be affected by the migratory activities connected with breeding and feeding during flooding. Fish movements are controlled by ecological conditions and the diversity of a community in one area could be affected by changes in the adjacent area (Olele *et al.,* 2008). According to Oguntade *et al*., (2014), fisheries resources are on the decline in the Niger Delta and this they have attributed to over-exploitation and inadequate management of the coastal ecosystems. This paper is aimed at providing benchmark information on the fish species composition, spatial and seasonal variations in Essene Creek.

Materials and Methods

Study Area

Essene Creek is located in Akwa Ibom State between latitude 4^0 35^l N and 4^0 50^l N and between longitude 7^0 30^l E and 7^0 44^l E. The climate of the area is that of humid tropic. Temperatures are moderate, typically lying between 26°C and 28°C. Rainfall is heavy and the mean annual rainfall lies between 2,000-4,000 mm. The wind is generally cold throughout the day, but gets much colder as evening sets in. Usually, the rainy season sets in between March and lasts till October, while the dry season takes the remainder of the year (November – April).

Fish Samples Collection

Monthly samples were collected for 12 calendar months, from April 2021 to March 2022 from artisanal fishers' landings. Fish samples were transported to the Fisheries Laboratory of the Department of Fisheries and Aquatic Environmental Management, University of Uyo, Uyo. In the laboratory, the fish samples were preserved in 10% diluted formaldehyde solution in a container, to prevent microbial activities.

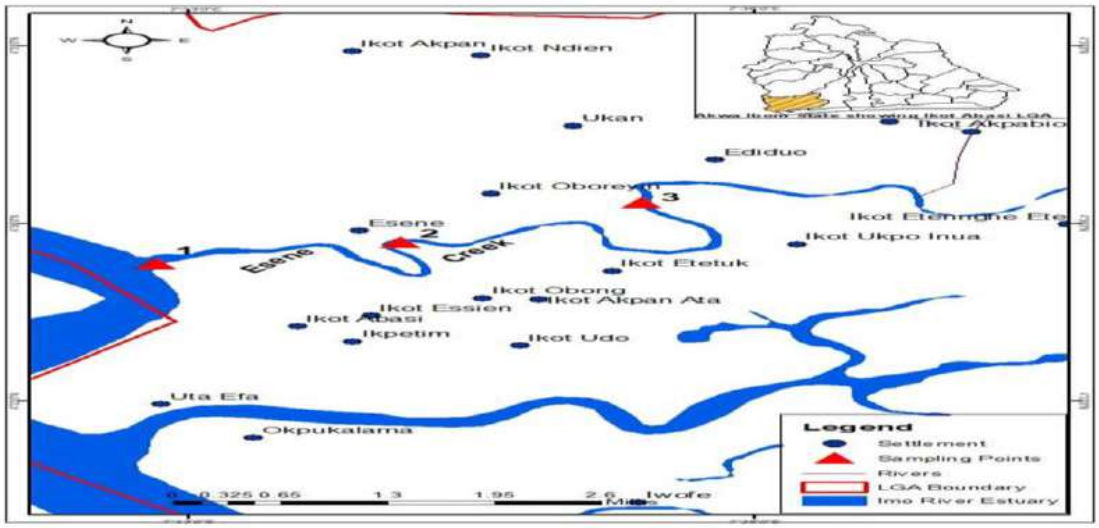

Fig. 1: Map of Essene Creek showing the three sampling stations (Insert: Map of Akwa Ibom State showing the location of Ikot Abasi LGA)

Fish samples identification and measurements

All preserved specimens were removed from the formaldehyde solution, rinsed in clean water and placed slantingly with the mouth down to drain out excess fluid for about 5 minutes prior to identification in order not to impose additional weight during weighing. Specimens were identified from family to species levels with

the aid of identification keys such as FAO/UN (1970); Olaosebikan and Raji, (1988); FAO (1990); Teugels *et al*., (1992); Edwards *et al.,* (2001); Idodo-Umeh (2005) and Adesulu and Sydenham (2007). Total length (TL, cm) of individual fish was measured to the nearest 0.1 cm as the length from the tip of the snout of the fish to the tip of the farthest caudal fin using a 1-50 cm range Measuring Board. Body weight (TW, g) of individual fish was also measured to the nearest 0.1g using an electronic kitchen scale (SF-40).

Data Analyses

Generated data were subjected to measures of dispersion using SAS (2009).

Abundance

Relative abundance was calculated as RF = $n_1/N \times 100$ ---------- (1)

Index of Preponderance was estimated using the equation:

$$IP(\%) = \frac{(\%N.\%W) \times 100}{\Sigma(\%N.\%W)} \text{ ---------- (2)}$$

Where: N = Number of fish species;
W = Weight of fish species (g)

Fishes with IP values of less than 0.50 were regarded as making insignificant contributions while those with IP values greater than 0.50 were considered in making significant contributions. (Moses, 1987). IP expresses the percentages of the total number and total weight of fish caught (Watson and Balon, 1984a, b).

Results

Species Composition

A total of 123 specimens of fish were collected during the study period, which comprised of 37 species, 29 genera, 21 families and 9 orders as presented in Table 1.

The 9 fish orders are Carangiformes, Characiformes, Clupeiformes, Elopiformes, Mugiliformes, Osteoglossiformes, Perciformes, Polypteriformes and Siluriformes, while the families included Alestidae, Anabantidae, Carangidae, Channidae, Cichlidae, Clariidae, Claroteidae, Clupeidae, Distichodontidae, Eleotridae, Elopidae, Gobiidae, Haemulidae, Hepsetidae, Latidae, Mochokidae, Monodactylidae, Mugilidae, Nanidae, Notopteridae, and Polyteridae. Out of the 9 fish orders sampled, the least number of species was observed in the order Carangiformes, Elopiformes, Mugiliformes, Osteoglossiformes, and Polypteriformes (1 species; 2.70%) while the highest number of species was obtained in the order Percifomes (20 species; 54.05%).in descending order, the remaining fish orders made the following contributions: Siluriformes (5 species; 13.51%), Characiformes (4 species; 10.81%) and Clupeiformes (3 species; 8.10%).

Spatial variation in species composition

The percentage abundance in terms of number of specimens of fish species sampled in the three sampling station stations showed a steadily and progressive increase downstream as follows: 18 individuals (14.63%), 20 individuals (16.26%) and 85 individuals (69.11%) for stations 1, 2 and 3 respectively out of the 123 individuals sampled (Table 1). In station 1, highest number of specimens was found in *Chrysichthys auratus* and *Eleotris vittata* (3 specimens; 16.67%) while no specimens were recorded in 23 species occurring in other stations. However, only 1 specimen (5.55%) was recorded in 12 species (*Alestes longipinnis, Chromidotilapia guntheri, Chrysichthys nigrodigitatus, Coptodon zilli, Hemichromis fasciatus, Lates niloticus, Nandus nadus, Oreochromis aureus, Pomadasys jubelini, P. rogerii, Psettius sebae, Synodontis filamentous* and *Trachinotus teraia*).

Seasonal Abundance

Ichthyofaunal abundance and diversity were higher in the wet season (69.92%) than in the dry season (30.08%) as shown in (Table 3 and Fig. 2).

Table 1: Spatial variations of the fish species in Essene Creek, Ikot Abasi LGA, Niger Delta, Nigeria

Order/Family/Species	Stations			N (%)
	1 (%)	2 (%)	3 (%)	
Carangidae				
Trachinotus teraia	1 (5.55)	0 (0.00)	1 (1.17)	2 (1.62)
Total Carangidae	**1 (5.55)**	**0 (0.00)**	**1 (1.17)**	**2 (1.62)**
Total Carangiformes	**1 (5.55)**	**0 (0.00)**	**1 (1.17)**	**2 (1.62)**
Alestidae				
Alestes longipinnis	0 (0.00)	0 (0.00)	1 (1.17)	1 (0.81)
Total Alestidae	**0 (0.00)**	**0 (0.00)**	**1 (1.17)**	**1 (0.81)**
Anabantidae				
Ctenopoma petherici	0 (0.00)	1 (5.00)	0 (0.00)	1 (0.81)
Total Anabantidae	**0 (0.00)**	**1 (5.00)**	**0 (0.00)**	**1 (0.81)**
Distichodontidae				
Nannethiops unitaeniatus	0 (0.00)	0 (0.00)	2 (2.35)	2 (1.62)
Total Distichodontidae	**0 (0.00)**	**0 (0.00)**	**2 (2.35)**	**2 (1.62)**
Hepsetidae				
Hepsetus odoe	0 (0.00)	0 (0.00)	1 (1.17)	1 (0.81)
Total Hepsetidae	**0 (0.00)**	**0 (0.00)**	**1 (1.17)**	**1 (0.81)**
Total Characiformes	**0 (0.00)**	**1 (5.00)**	**4 (4.70)**	**5 (4.06)**
Clupeidae				
Cynothrissa mento	0 (0.00)	0 (0.00)	27 (31.76)	27 (21.95)
Denticeps clupeoides	0 (0.00)	2 (10.00)	0 (0.00)	2 (1.62)
Sierrathrissa leonensis	0 (0.00)	1 (5.00)	0 (0.00)	1 (0.81)
Total Clupeidae	**0 (0.00)**	**3 (15.00)**	**27 (31.76)**	**30 (24.39)**
Total Clupeiformes	**0 (0.00)**	**3 (15.00)**	**27 (31.76)**	**30 (24.39**
Elopiformes				
Elopidae				
Elops lacerta	0 (0.00)	0 (0.00)	1 (1.17)	1 (0.81)
Total Elopidae	**0 (0.00)**	**0 (0.00)**	**1 (1.17)**	**1 (0.81)**
Total Elopiformes	**0 (0.00)**	**0 (0.00)**	**1 (1.17)**	**1 (0.81)**
Mugiliformes				
Mugilidae				
Liza dumerili	0 (0.00)	0 (0.00)	1 (1.17)	1 (0.81)
Total Mugilidae	**0 (0.00)**	**0 (0.00)**	**1 (1.17)**	**1 (0.81)**
Total Mugiliformes	**0 (0.00)**	**0 (0.00)**	**1 (1.17)**	**1 (0.81)**
Notopteridae				
Papyrocranus afer	0 (0.00)	2 (10.00)	3 (3.52)	5 (4.06)
Total Notopteridae	**0 (0.00)**	**2 (10.00)**	**3 (3.52)**	**5 (4.06)**
Total steoglossiformes	**0 (0.00)**	**2 (10.00)**	**3 (3.52)**	**5 (4.06)**
Perciformes				
Cichlidae				

Order/Family/Species	Stations			N (%)
	1 (%)	2 (%)	3 (%)	
Coptodon guineensis	0 (0.00)	0 (0.00)	1 (1.17)	1 (0.81)
C. zilli	1 (5.55)	0 (0.00)	0 (0.00)	1 (0.81)
Hemichromis elongatus	0 (0.00)	0 (0.00)	2 (2.35)	2 (1.62)
H. fasciatus	1 (5.55)	4 (20.00)	22 (25.88)	27 (21.95)
H. bimaculatus	0 (0.00)	0 (0.00)	1 (1.17)	1 (0.81)
Oreochromis aureus	1 (5.55)	0 (0.00)	1 (1.17)	2 (1.62)
O. niloticus	0 (0.00)	1 (5.00)	0 (0.00)	1 (0.81)
Sarotherodon galilaeus	0 (0.00)	0 (0.00)	1 (1.17)	1 (0.81)
S. melanotherodon	0 (0.00)	0 (0.00)	3 (3.52)	3 (2.24)
Total Cichlidae	**3 (16.66)**	**8 (40.00)**	**32 (37.64)**	**43 (34.95)**
Channidae				
Parachanna africana	0 (0.00)	0 (0.00)	3 (3.52)	3 (2.43)
Total Channidae	**0 (0.00)**	**0 (0.00)**	**3 (3.52)**	**3 (2.43)**
Eleotridae				
Bostrychus africanus	1 (5.55)	0 (0.00)	0 (0.00)	1 (0.81)
Eleotris senegalensis	0 (0.00)	2 (10.00)	0 (0.00)	2 (1.62)
E. vittata	3 (16.67)	2 (10.00)	0 (0.00)	5 (4.06)
Total Eleotridae	**4 (22.22)**	**4 (20.00)**	**0 (0.00)**	**8 (6.50)**
Gobiidae				
Periophthalmus barbarous	0 (0.00)	0(0.00)	1 (1.17)	1 (0.81)
Total Gobiidae	**0 (0.00)**	**0(0.00)**	**1 (1.17)**	**1 (0.81)**
Haemulidae				
Pomadasys jubelini	1 (5.55)	0(0.00)	1 (1.17)	2 (1.62)
P. rogerii	1 (5.55)	0(0.00)	0 (0.00)	1 (0.81)
Total Haemulidae	**2 (11.11)**	**0(0.00)**	**1 (1.17)**	**3 (2.43)**
Lattidae				
Lates niloticus	1 (5.55)	2(10.00)	1 (1.17)	4 (3.25)
Total Lattidae	**1 (5.55)**	**2(10.00)**	**1 (1.17)**	**4 (3.25)**
Monodactylidae				
Psettius sebae	1 (5.55)	0 (0.00)	1 (1.17)	2 (0.62)
Total Monodactylidae	**1 (5.55)**	**0 (0.00)**	**1 (1.17)**	**2 (0.62)**
Nanidae				
Nandus nadus	1 (5.55)	0 (0.00)	0 (0.00)	1 (0.81)
Total Nanidae	**1 (5.55)**	**0 (0.00)**	**0 (0.00)**	**1 (0.81)**
Total Perciformes	**12 (66.66)**	**16 (80.00)**	**42 (49.41)**	**70 (56.91)**
Polypteriformes				
Polypteridae				
Erpetoichthys calabaricus	0 (0.00)	0 (0.00)	3(3.52)	3 (2.43)
Total Polypteridae	**0 (0.00)**	**0 (0.00)**	**3(3.52)**	**3 (2.43)**
Total Polypteriformes	**0 (0.00)**	**0 (0.00)**	**3(3.52)**	**3 (2.43)**

Order/Family/Species	Stations			N (%)
	1 (%)	2 (%)	3 (%)	
Siluriformes				
Clariidae				
Heterobranchus bidorsalis	0 (0.00)	0 (0.00)	3 (3.52)	3 (2.43)
Total Clariidae	**0 (0.00)**	**0 (0.00)**	**3 (3.52)**	**3 (2.43)**
Claroteidae				
Chrysichthys auratus	3 (16.67)	0 (0.00)	2 (2.35)	5 (4.06)
C. nigrodigitatus	1 (5.55)	0 (0.00)	0 (0.00)	1 (0.81)
Total Claroteidae	**4 (22.22)**	**0 (0.00)**	**2 (2.35)**	**6 (4.87)**
Mochokidae				
Synodontis filamentosa	1 (5.55)	0 (0.00)	0 (0.00)	1 (0.81)
S. sorex	0 (0.00)	0 (0.00)	1 (1.17)	1 (0.81)
Total Mochokidae	**1 (5.55)**	**0 (0.00)**	**1 (1.17)**	**2 (1.62)**
Total Siluriformes	**5 (27.78)**	**0 (0.00)**	**6 (7.06)**	**11 (8.94)**
Grand Total	**18 (100)**	**20 (100)**	**85 (100)**	**123 (100)**

Note: N = Total number of specimens sampled

Wet season abundance revealed 86 specimens of fish represented by thirty-two fish species. Of the total number of species sampled, the following species (5) were absent during the wet season: *Alestes longipinnis, Coptodon zilli, Hepsetus odoe, Nannethiops unitaeniatus* and *Synodontis sorex.*

Dry season abundance showed that there were 14 species comprising of 37 specimens. Of the 37 species sampled from Essene Creek, twenty-two species: *Bostrychus africanus, Chrysichthys nigrodigitatus, Coptodon guineensis, Cynothrissa mento, Denticeps clupeoides, Eleotris vittata, Elops lacerta, Hemichromis bimaculatus, Hemichromis elongatus, Liza dumerili, Nandus nadus, Nannethiops unitaeniatus, Oreochromis aureus, Oreochromis niloticus, Periophthalmus barbarus, Pomadasys rogerii, Psettus sebae, Sarotherodon galilaeus, Sarotherodon melanotherodon, Sierrathrissa leonensis, Synodontis filamentosa* and *Trachinotus teraia* were absent during the dry season.

Based on the index of preponderance, *Bostrychus africanus, Denticeps clupeoide, Sierrathrissa leonensis made* the least contribution (0.01%) whereas *Hemichromis fasciatus* made the highest contribution (70.07%) to the total fish species abundance (Table 2 and Fig. 3). Twenty-six species: *Alestes longipinnis, Bostrychus africanus, Coptodon guineensis, Coptodon zilli, Ctenopoma petherici, Denticeps clupeoides, Eleotris vittata, Eleotris senegalensis, Elops lacerta, Hemichromis bimaculatus, Hemichromis elongatus, Hepsetus odoe, Heterobranchus bidorsalis, Liza dumerili, Nandus nadus, Nannethiops unitaeniatus, Oreochromis niloticus, Parachanna africana, Periophthalmus barbarus, Pomadasys rogerii, Psettus sebae, Sarotherodon galilaeus Sierrathrissa leonensis, Synodontis filamentosa, Synodontis sorex,* and *Trachinotus teraia,* contributed insignificantly to the fishery of Essene Creek while the twelve species *Chromidotilapia guntheri, Chrysichthys auratus, C. nigrodigitatus, Cynothrissa mento, Erpetoichthys calabaricus, Hemichromis fasciatus, Lates niloticus, Oreochromis aureus, Papyrocranus afer, Pomadasys jubelini* and *Sarotherodon melanotherodon* had significant contributions.

Table 2: Seasonal and pool abundance (%IP) fish species in Essene Creek, Ikot Abasi LGA, southern Nigeria.

Species	Dry Season (%)	Wet Season (%)	%IP
Alestes longipinnis	1 (2.70)	0 (0.00)	0.03
Bostrychus africanus	0 (0.00)	1 (1.16)	0.01
Chromidotilapia guntheri	1 (2.70)	3 (3.48)	0.68
Chrysichthys auratus	2 (5.40)	3 (3.48)	7.96
C. nigrodigitatus	0 (0.00)	1 (1.16)	0.55
Coptodon guineensis	0 (0.00)	1 (1.16)	0.06
C. zilli	1 (2.70)	0 (0.00)	0.14
Ctenopoma petherici	0 (0.00)	1 (1.16)	0.17
Cynothrissa mento	0 (0.00)	27 (31.39)	2.07
Denticeps clupeoides	0 (0.00)	2 (2.32)	0.01
Eleotris senegalensis	0 (0.00)	2 (2.32)	0.06
E. vittata	0 (0.00)	5 (5.81)	0.48
Elops lacerta	0 (0.00)	1 (1.16)	0.12
Erpetoichthys calabaricus	2 (5.40)	1 (1.16)	0.51
Hemichromis bimaculatus	0 (0.00)	1 (1.16)	0.12
H. elongatus	0 (0.00)	2 (2.32)	0.06
H. fasciatus	16 (43.24)	11 (12.79)	70.07
Hepsetus odoe	1 (2.70)	0 (0.00)	0.10
Heterobranchus bidorsalis	1 (2.70)	2 (2.32)	0.21
Lates niloticus	3 (8.10)	1 (1.16)	1.33
Liza dumerili	0 (0.00)	1 (1.16)	0.35
Nandus nadus	0 (0.00)	1 (1.16)	0.02
Nannethiops unitaeniatus	2 (5.40)	0 (0.00)	0.09
Oreochromis aureus	0 (0.00)	2 (2.32)	2.04
O. niloticus	0 (0.00)	1 (1.16)	0.03
Papyrocranus afer	2 (5.40)	3 (3.48)	10.21
Parachanna africana	1 (2.70)	2 (2.32)	0.27
Periophthalmus barbarus	0 (0.00)	1 (1.16)	0.03
Pomadasys jubelini	1 (2.70)	1 (1.16)	0.63
P. rogerii	0 (0.00)	1 (1.16)	0.09
Psettus sebae	0 (0.00)	2 (2.32)	0.06
Sarotherodon galilaeus	0 (0.00)	1 (1.16)	0.06
S. melanotherodon	0 (0.00)	3 (3.48)	0.74
Sierrathrissa leonensis	0 (0.00)	1 (1.16)	0.01
Synodontis filamentosa	0 (0.00)	1 (1.16)	0.11
S. sorex	1 (2.70)	0 (0.00)	0.23
Trachinotus teraia	0 (0.00)	1 (1.16)	0.30
Total	**37 (30.08)**	**86 (69.92)**	**100**

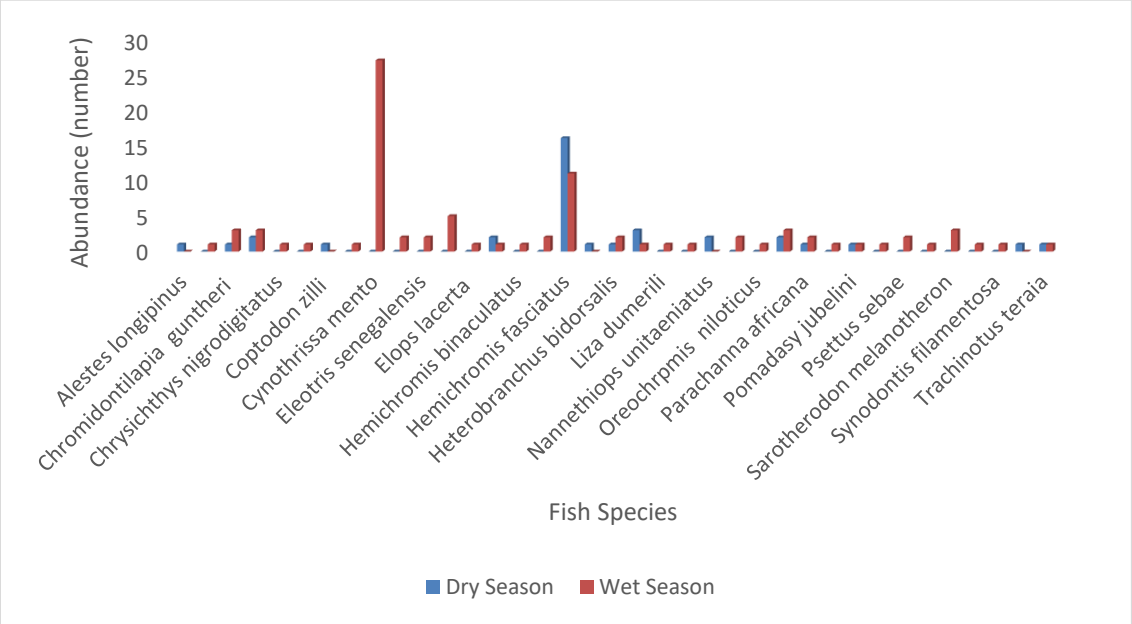

Fig. 2: Seasonal abundance of the fish species sampled in Essene Creek, Ikot Abasi L.G.A., southern, Nigeria

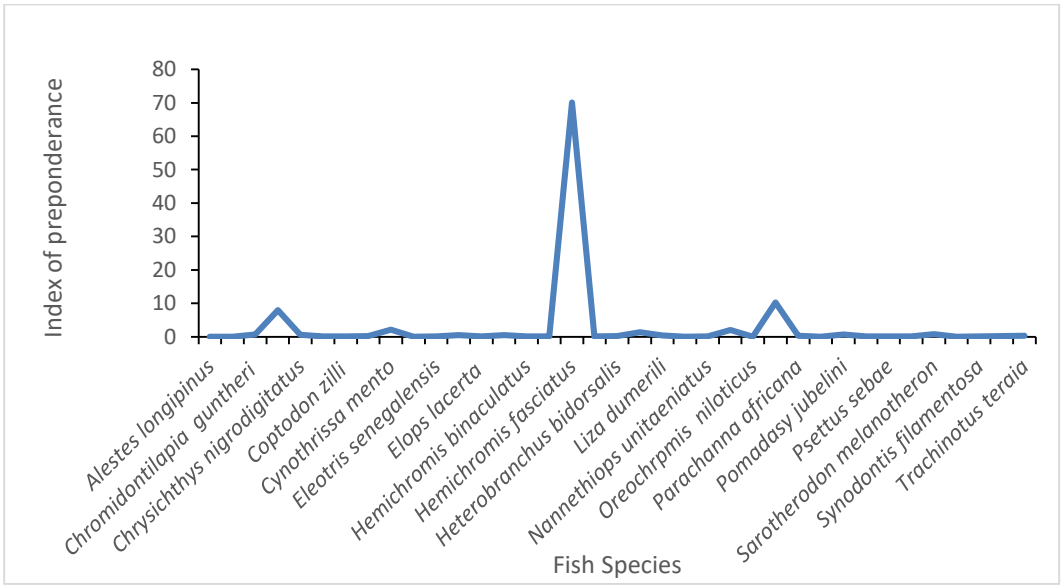

Fig. 3: Index of Preponderance of the fish species sampled in Essene Creek, Ikot Abasi, southern, Nigeria

Discussion

At station 1, *C. nigrodigitatus and E. vittata had* the highest number of specimens sampled (3 individuals; 16.67%) each. *E. vittata* occurred in station 1 (3 individuals) and 2 (2 individuals). This agrees with Ekpo *et al*., 2015 in the lower Cross River the seasonal variation in abundance of *E. vittata* was higher (121 specimens; 52.38%) during the wet season than the dry season (110 specimens; 47.62%). High water season has been considered as the main feeding and growing period for nearly all species in the seasonal flood plain rivers of the tropics. This contradicts the work reported by Chukwu (2022)

in the New Calabar River the seasonal abundance was 55.42% in the dry season while 44.58% was recorded in the wet season. Catch data (Monthly) for E. vittata was zero at the peak of the wet season (August-September) the significant higher catch observed in the dry season over the wet season could be linked to the fact that the gear used had a better performance in the dry season as a result of reduced water volume.

During the study period, there were higher catches in the Creek during the wet season compared to the dry season, 87 specimens (69.92%) in wet season while 36 specimens (30.08%) in the dry season. *Cynothrissa mento* was the dominant species of the wet season with a percentage value of 27 (31.39) followed by *C. guntheri, C. auratus and S. melanotheron* with the percentage value of 3 (3.48) respectively. The least abundant species of the wet season were *C. zilli, A. longipinnis, H. odoe, N. unitaeniatus, S. sorex* with a percentage value of 0 (0.00) respectively. For the dry season, the most abundant species was *H. fasciatus* with a percentage value of 16 (43.24), followed by *L. niloticus* 3(8.10) then *C. auratus, N. unitaeniatus, P. afer, E. calabaricus* with their respective percentage value of 2 (5.40). The least abundant species of the dry season were *B. africanus, C. nigodigitatus, C. guineensis, C. petherici, C. mento, D. clupeoides, E. senegalensis, E. vittata, E. lacerta, H. bimaculatus, H. elongatus, L. dumerlli, N. nadus O. niloticus. O. aureus* with a percentage value of 0 (0.00) respectively.

The higher fish catch in the Creek during the wet season could be attributed to increase in fish population density as it might probably be influenced by the availability of food (plankton), alloctonous materials, migration of euryhaline species, presence of depth of water, among other things. In a similar study, Solomon *et al*., (2012) reported high fish fauna during the wet season in Lower River Niger, Idah in Kogi State. Researchers like Odulate (2010) recorded higher catches in the rainy month of July in Ode-Omi coastal marine waters of Ogun State, Nigeria. Oginni (2004) in Iwo reservoir and Bello-Olusoji (1998) in Asejire Dam, Nigeria observed higher fish catches during the wet season attributing it to the draw-down effect of water volume in Lakes and reservoirs to be responsible for the higher catches as cited in Bamidele and Okeowo (2017).

Seasonal differentiation evident in higher number of species and individuals caught during wet months of the study period, agrees with other results which described larger ichthyofaunal densities in water bodies in Grahamstown in the rainy season. (Karlman, 1982, Oke, 1990; Offem and Ikpi 2012). This was also attributed to seasonal differences in dissolved oxygen concentration in the system, both at low water and during the floods; this factor appears to have played an essential role in determining the distribution of fish within the system (Karlman, 1982). The wet season had higher species composition and abundance than the dry season which is due to the rise in water levels, increased run-off from nutrients rich agricultural lands which are carried into the water body (Offem *et al.,* 2011). Omoike (2021) The Fishes caught during wet seasons were more both in species, number and weight than the fishes caught during the dry periods. This present work is in contrast with the reported works of Adadu *et al*., (2019), that the month of November marks the beginning of the dry season with its attendant low water level that makes the fish more vulnerable to capture; Ikenna *et al.,* (2017) reported that the abundance of the fish fauna in Otamiri River was dependent on season as more fishes were captured in dry season than in wet season,more species were also recorded and with high diversity indices in the dry season than in the wet season in all the stations, according to the author. The present study provided evidence that fluctuations in River flow can influence the seasonal occurrence and distribution patterns of several freshwater fish species. The Seasonal

differentiation in the peak in abundance of the 37 fish species, in Essene Creek could be influenced by the peak in water level, migratory season and light intensity of the season which could have led to the biological productivity of the Creek.

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Ichthyofaunal Composition And Spatio-Temporal Abundance In Kono Creek, Khana, Rivers State, Nigeria

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Abstract: *Fish species composition and spatio-temporal abundance in a Niger Delta coastal tributary was carried out from August, 2018 to July, 2019 in three sampling stations designated as stations A, B and C using standard analytical methods. The findings depicted that a total of one thousand five hundred and sixty-nine (1,569) fish specimens were collected consisting of nine (9) orders, twenty-one (21) families, seven (7) genera and fifty (50) species. The poly-diverse fish orders recorded in ascending ordercomprised:Characiformes>Cypriniformes>Cichliformes>Siluriformes>Pleuriformes>Mugiliforme>Scomb riformes>Clupeiformes>Perciformes. The most abundant species were: Pseudotolithus elongatus (330 specimens; 21.03%), followed by Ethmalosa fimbriata (289 specimens; 18.43%), Scomberomorus tritor (122 specimens; 7.78%), Caranx latus (114 specimens; 7.72%), Syacium micrurum (67 specimens; 4.27%) and Eucinostomus melanopterus (51 specimens; 3.25%) while the least species which constituted 1 specimen (0.06%) each included: Cephalopholus nigri, Citharichthys stampflii, Heteromycteris proboscideus, Lobotes surinamensis, Lutjanus goreensis, Sarotherodon galilaeus, and Thunnus obesus. Based on the IP, ten of the species sampled made significant contributions while the remaining 40 species had insignificant contributions; P. elongatus having the highest contribution (47.50%) to the fishery of Kono Creek. Temporal variations revealed that highest occurrence was in March (167 specimens; 10.64%), followed October (157 specimens; 10.00%), August and April (152 specimens; 9.69%) each, December (140 specimens; 8.92%), and May (130 specimens; 8.29) while November recorded the least (108 specimens; 6.88%). Spatial variation showed that station A had the highest abundance (635 individuals; 40.47%) whereas the least was reported in station C (504 individuals; 32.12%), station B was observed to record (430 individuals; 27.41%). These findings will aid in formulating policies for effective management of the fishery resources in the Creek so as to enhance sustainable fish production, thus, improving the standard of living among the fishers in the fishing communities and environs.*

Keywords: abundance, Kono Creek, ichthyofauna composition, specimens, spatio-temporal

CITATION:

Ekpo, I. E., Ndakor, N. P., Dodeye, E. O, and Udoh, J. P. (2023). Ichthyofaunal Composition and Spatio-Temporal Abundance in Kono Creek, Khana, Rivers State, Nigeria. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 213-223

Introduction

Fish are rich sources of protein, essential fatty acids, vitamins and minerals Ibim and Bongilli, 2018. Fagade (1992) reported that fish flesh is about the best source of animal protein, better digested than beef and poultry, and it contains a good quality and quantity of mineral salts. Also, fish oil is a poly-unsaturated fatty acid with anti-cholesterol factor. He concluded that regular consumption of fish is beneficial to human body.

Fish from capture fishery is on the decline in Nigeria due to over exploitation and inadequate management of her coastal waters. For sustainability of fisheries resources, assessment and documentation of the status of the fish stock (species composition and abundance of fish fauna) is pertinent. Fish communities inhabiting the estuaries, creeks and other coastal brackish water consist of both fresh water and marine fish species, often referred as euryhaline species (Teugels *et al*., 1992; Ekpo and Udo, 2013; Ekpo *et al*., 2014; Ibim and Bongilli, 2018).

According to Abiodun and Miller (2005) cited in Peter *et al*., (2015), catch composition, frequency of size and increase or decrease in total catch are not reliable for most inland waters of Nigeria for more than two decades. Development and improved management of any country's water bodies must therefore start with increased knowledge of the water bodies, information on the current status of fisheries and the socio-economic characteristics of fishing communities so that people can be effectively integrated into co-management programmes. Fish are not infinite resources and therefore requires good, long-term management and protection from over-exploitation. Lack of substantial data implies poor management and the trend of fish catches is on the decline due to over-harvesting among other factors (Ekundayo *et al.*, 2014). Poor management of water bodies by relevant government authorities in Nigeria has led to low productivity and consequently low catches by fishers. This has led to the use of undesirable fishing gears and very destructive fishing methods with the sole aim of getting more catch (Peter *et al.,* 2015). Coastal creeks contribute significantly to the fisheries of any society but the effectiveness of their contributions depends largely on adequate fish assemblages and their proper management. Several studies carried out on fish species composition in the Niger Delta are: Jackson *et al*., (2018), Ekpo and Udoh (2013), Daniel and Monsi, (2013), (2019) and Lawson *et al.,* (2013), among others.

According to Peter *et al.,* (2015), fish is one of the cheapest sources of animal protein available to man, there is need to protect and manage them. In order for this to be realistic and effective, detailed knowledge of the water bodies and the fishes inhabiting them is of great importance. Today in Nigeria and other parts of the world, there are a number of growing concerns about problems with the management of fisheries resources and fishing, placing excessive strain on the on the aquatic ecosystems. Consequently, the history of management of inland fisheries worldwide shows low success in contending the growing fishing pressures on the natural resources (Matthew, 2000). Reporting of creek and inland fisheries production continues to present problems owing to lack of reliable information on catch quantities and species composition (Dan-Kishiya, 2012). Fisheries management requires a good knowledge of fishing gears (Idowu *et al*., 2004), fish species composition, fish quantities and fishers (Peter *et al*., 2015). Fish species composition and their spatio-temporal abundance in Kono Creek, Rivers State in the Niger Delta region of Nigeria is the aim of this study**.**

Materials and Methods

Description of the Study area

The study was carried out in Kono Creek in Khana Local Government Area, Rivers State, Nigeria. It is bounded by Oyigbo in the north, Opobo in the south, Andoni and Gokana in the west and Ikot Abasi in the east (Fig. 1). The Creek is a tributary of Imo River and is located between longitude $7^{0}30'4.86'E$ and latitude $4^{0}35'16.64'N$ in the Eastern part of the Niger Delta. The Netherlands Engineering Consultants, (1961) described Kono Creek as a short Creek entering the Imo River near mile 8 on the western side. The vegetation of the Creek includes black mangroves (*Avicennia germinas*), button mangrove

(*Conocarpus erectus*), white mangroves (*Laguncularia racemosa*), red mangroves (*Rhizophora mangle, R. harrisonii, R. racemosa*), *Avicennia* (Zabbey and Tanee, 2016). Kono Creek's marginal vegetation is predominantly nipa palm (*Nypa fruticans*), which NEDECO (1961) wrongly described as a type of "Raphia palm" typical of the Imo River sector. It is an estuary with human anthropogenic activities such as fishing, transportation, settlement, laundry and dredging. Its climate is characterized by alternate wet and dry seasons: wet season period stretching from April to October. However, occasional precipitation occurs in the dry season months of November to March (Nigeria Meteorological Agency, NMA 2008). It experiences two types of tide; the high and the low tides, with mudflat sediments. However, the tidal range changes throughout the months.

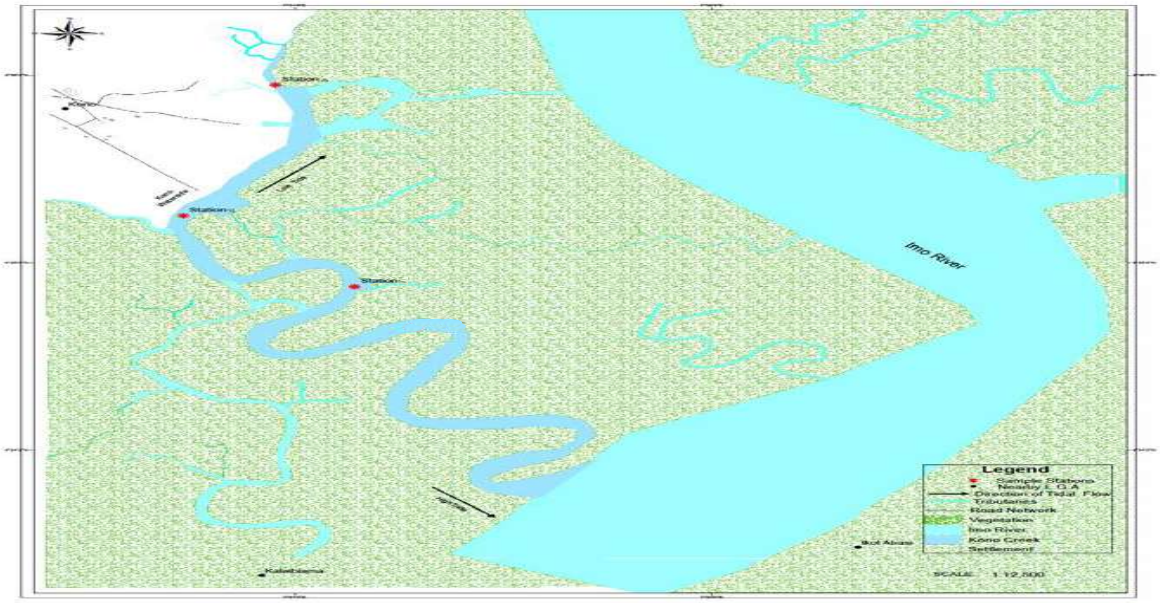

Fig. 1: Map of Kono Creek in Khana L.G.A., Rivers State, Nigeria

Sampling Stations

Three sampling stations were established along Kono Creek, with Latitude $4^035'44.07''$N and Longitude $7^031'2.03''$E in station 1, Latitude $4^035'5.37''$N and Longitude $7^030'45.62''$E in station 2 and Latitude $4^034'38.40''$N and Longitude $7^031'22.57''$E in station 3. The distance between stations 1 and 2 was 1.2 km while stations 2 and 3 was 1.2 km; and were purposefully selected based on fishing activities and accessibility.

Collection and Preservation of Fish Samples

Fish specimens were collected monthly from the established stations along the waterfront of Kono Creek using the artisanal fishers' landings. They were carried in ice-block crests and transported to Fisheries Laboratory, Department of Fisheries and Aquatic Environmental Management for preservation in 10% formaldehyde solution.

Identification and Morphometric measurement of the Specimens

Each specimen was removed from the formalin, rinsed in water and identified using appropriate field guides such as Wolfgang, 1990; Edwards *et al.,* 2001 and Idodo-Umeh, (2003). The body weight (TW, g) was taken using a weighing balance to the nearest 0.01g and total length (TL, cm), the distance from the tip of the snout to the tip of the longest lobe of the caudal

fin was recorded using a measuring board, to the nearest 0.1cm for each of the specimens.

Statistical Analysis

SPSS Statistics (v.20) was used to analyze the data obtained. Measures of dispersion were used to determine how homogenous or heterogenous the dataset were. Analysis of variance (ANOVA) was carried out on various stations, months and seasons.

Abundance

Relative frequency (RF)

$$R = \frac{n}{N} \times 100$$

Where: n = Number of species in the sample

N = Total number of individuals in the sample

Index of Preponderance (%IP)

$$\text{IP (\%)} = \frac{\%\text{N}.\%\text{W}}{\sum(\%\text{N}.\%\text{W})} \times 100$$

Where:

N = Number of individual species

W = Total number of species

Fishes with IP values less than (≤) 0.50 was regarded as being of relatively insignificant contribution while those with IP values greater than (≥) 0.50 was regarded as being significant contribution (Moses, 1987).

Results

The findings of the ichthyofaunal composition and spatio-temporal abundance in Kono Creek are presented below:

Size composition and relative abundance of fish species from Kono Creek

A total of one thousand five hundred and sixty-nine (1,569) fish specimens were collected during the period of the study, consisting of nine (9) orders, twenty-one (21) families, seven (7) genera and fifty (50) species. The poly-diverse fish orders recorded in ascending order comprise: Characiformes>Cypriniformes>Cichliformes>Siluriformes>Pleuriformes>Mugiliformes>Scombriformes>Clupeiformes>Perciformes. The most abundant species were: *Pseudotolithus elongatus* (330 specimens; 21.03%), followed by *Ethmalosa fimbriata* (289 specimens; 18.43%), *Scomberomorus tritor* (122 specimens; 7.78%), *Caranx latus* (114 specimens; 7.72%), *Syacium micrurum* (67 specimens; 4.27%) and *Eucinostomus melanopterus* (51 specimens; 3.25%) while the least species which constituted 1 specimen (0.06%) each included: *Cephalopholus nigri, Citharichthys stampflii, Heteromycteris proboscideus, Lobotes surinamensis, Lutjanus goreensis, Sarotherodon galilaeus,* and *Thunnus obesus* (Table 1).

Table 1 presents the species composition by number (%) and weight (g), Index of Preponderance and size composition of fish species obtained in Kono Creek. *P. elongatus* (11339.43 g) followed by *E. fimbriata* (8899.88 g) were the most species sampled by weight. *C. stampflii* (8.5 g) followed by *S. guachancho* (5.92 g) were least species encountered by weight. *P. elongatus* (47.49%) had the highest abundance, followed by *E. fimbriata* (32.65%) and *B. longipinnis* (5.54%). *C. stampflii, T. teraia, T. obesus, S. guachancho, H. proboscideus and C. nigri* had the least Index of Preponderance (0.00%) respectively. Ten of the species sampled are significant contribution (*C. latus, E. fimbriata, E. buffei, L. grandisquamis, P. leonensis, P. rogerri, P. elongatus, P. senegalensis, S. tritor, and S. micrurum*) while the remaining 40 species are insignificant contribution. Fig. 2 is the graphical presentation of the relative abundance of fish species sampled.

Table 1: Species composition in (g) and number (%), and Index of Preponderance of fish species sampled in Kono Creek, Nigeria

Species	N	%N	TL cm Wet	Dry	TW g	%W	%N%W	%IP
Alestes alexandrines	3	0.19	-	10.63	34.80	0.07	0.01	0.00
Barbus callipterus	13	0.83	14.55	17.34	381.3	0.81	0.67	0.06
Caranx hippos	7	0.45	8.90	10.55	109.36	0.23	0.10	0.01
C. latus	114	7.27	12.08	13.39	2748.27	5.82	42.28	3.98
Cephalopholis nigri	1	0.06	17.40	-	33.1	0.07	0.00	0.00
Chloroscombrus chrysurus	5	0.32	13.10	-	78.2	0.17	0.05	0.01
Chrysichthys nigrodigitatus	18	1.15	15.37	16.43	701.39	1.49	1.70	0.16
Citharichthys stampflii	1	0.06	26.10	-	8.5	0.02	0.00	0.00
Cynoglossus senegalensis	6	0.38	19.55	14.35	181.25	0.38	0.15	0.01
Ethmalosa fimbriata	289	18.42	14.22	14.02	8899.88	18.85	347.13	32.64
Eucinostomus melanopterus	51	3.25	10.24	12.89	878.57	1.86	6.05	0.57
Eutropiellus buffei	2	0.13	34.05	-	53.4	0.11	0.01	0.00
Galeoides decadactylus	25	1.59	14.41	13.87	644.64	1.37	2.18	0.21
Hepsetus odoe	7	0.45	10.16	-	103.44	0.22	0.10	0.10
Heteromycteris proboscideus	1	0.06	14.10	-	26.18	0.06	0.00	0.00
Ilisha africana	15	0.96	17.19	14.50	551.37	1.17	1.11	0.11
Liza dumerilii	29	1.85	15.17	11.82	808.16	1.71	3.16	0.30
L. falcipinnis	37	2.36	12.29	12.13	768.92	1.63	3.84	0.36
Liza grandisquamis	40	2.55	14.20	11.81	1154.31	2.44	6.23	0.59
Lobotes surinamensis	1	0.06	-	19.30	53.6	0.11	0.01	0.00
Lutjanus agennes	3	0.19	8.20	-	30.86	0.07	0.01	0.00
Lutjanus goreensis	1	0.06	15.30	-	43.26	0.09	0.01	0.00
Mugil bananensis	4	0.25	25.60	16.45	281.4	0.60	0.15	0.01
M. cephalus	4	0.25	13.23	10.50	51.52	0.11	0.03	0.00
Mugil curema	6	0.38	9.74	13.40	74.4	0.16	0.06	0.01
Parailia pellucida	19	1.21	17.72	-	383.45	0.81	0.98	0.09
Pellonula leonensis	41	2.61	14.48	17.10	1305.41	2.75	7.22	0.68
Pentanemus quinquarius	7	0.45	9.74	13.40	71.5	0.15	0.07	0.01
Polydatylus quadrifilis	46	2.93	17.72	-	679.29	1.44	4.22	0.40
Pomadasys jubelini	3	0.19	14.48	17.10	68.9	0.15	0.03	0.00
P. speroteti	31	1.98	10.95	10.40	726.93	1.54	3.04	0.29
P. rogerii	47	3.00	10.17	12.70	1225.61	2.60	7.77	0.73
Psettias sebae	28	1.78	10.90	18.10	905.98	1.92	3.42	0.32
Pseudotolithus brachygnathus	10	0.64	12.12	23.20	200.9	0.43	0.27	0.03
P. elongatus	330	21.03	11.12	15.79	11339.0.	24.01	505.02	47.50
P. epipercus	4	0.25	14.89	14.50	163.1	0.35	0.08	0.01
P. senegalensis	36	2.29	11.96	-	1276.71	2.70	6.20	0.58
Sardinella aurita	15	0.96	14.84	16.96	176.5	0.37	0.36	0.03
Species	**N**	**%N**	**TL cm Wet**	**Dry**	**TW g**	**%W**	**%N%W**	**%IP**
Scomberomorus tritor	122	7.78	14.28	18.73	5210.26	11.03	85.79	8.07
Sierrathrissa leonensis	12	0.76	10.80	-	334.86	0.71	0.54	0.05

Sphyraena afra	20	1.27	25.50	16.23	920.98	1.95	2.49	0.23
S. guachancho	3	0.19	16.56	13.60	5.92	0.01	0.00	0.00
Syacium micrurum	67	4.27	14.11	14.50	1917.32	4.06	17.34	1.63
Thunnus obesus	1	0.06	-	-	25.49	0.05	0.00	0.00
Tilapia dageti	13	0.83	11.87	-	338.05	0.72	0.59	0.06
T. guineensis	3	0.19	13.63	-	28.37	0.06	0.01	0.00
T. mariae	4	0.25	16.75	-	194.12	0.41	0.10	0.01
Trichinotus teraia	2	0.13	-	10.25	17.02	0.04	0.00	0.00
Trichiurus lepturus	21	1.34	12.30	16.69	949.85	2.01	2.69	0.25
Total	**1,569**							

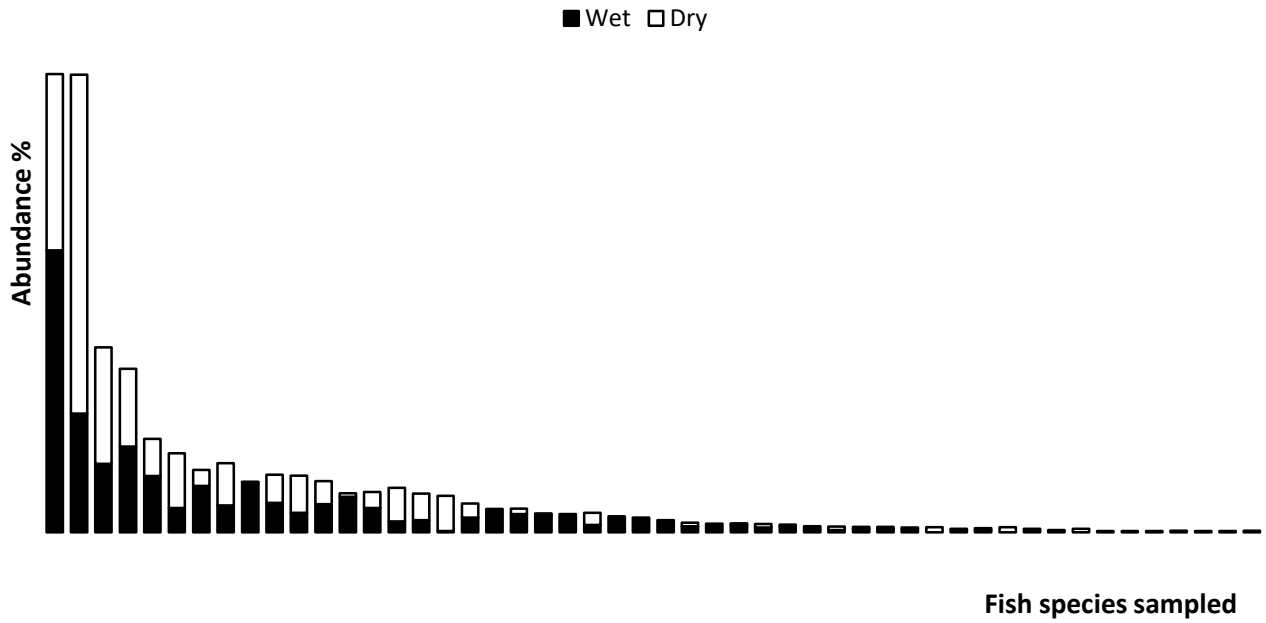

Fig. 2: Seasonal percentage abundance of fish species in Kono Creek, Nigeria

Seasonal variation

Seasonal abundance was higher during wet season (forty-six species) than the dry season (thirty-four species) (Table 1 and Fig. 2). Only four species (*A. alexandrines, L. surinamensis, Th. obesus* and *T. teraia*) were absent during the wet season whereas sixteen species (*C. nigri, Chl. chrysurus, C. stampflii, E. buffei, H. proboscideus, H. odoe, L. agennes, L. goreensis, P. pellucida, Th. obesus, P. quadrifilis, P. senegalensis, S. leonensis, T. dageti, T. guineensis* and *T. mariae*) were missing during the dry season.

Spatio-temporal variation

Spatial variability was found not to exist in the means of the three sampling stations, not significantly different ($p>0.5$). It showed that station A had the highest abundance (635 individuals; 40.47%) whereas the least was reported in station C (504 individuals; 32.12%), station B was observed to record (430 individuals; 27.41%).

Monthly means were statistically different at $p<0.05$ and were separated into five groups (Table 2). Temporal variations revealed that highest abundance was in March (167 specimens; 10.64%) (21.88±1.13), followed

October (157 specimens; 10.00%) (25.35±1.12), August (28.01±0.74) and April (31.05±1.10) (152 specimens; 9.69%) each, December (140 specimens; 8.92%) (23.73±1.34), and May (130 specimens; 8.29) (18.08±1.04) while November recorded the least abundance (108 specimens; 6.88%) (23.63±1.40) (Table 2).

Table 2: Spatio-temporal variation in fish abundance in Kono Creek, Nigeria

Month	N	N%	Stations A	B	C	Mean±Std. Error
Aug	152^{c,d}	9.69	121	17	14^{ns}	28.01±0.74
Sep	127^{d}	8.09	35	37	55^{ns}	30.71±0.90
Oct	157^{b,c}	10.00	65	45	47^{ns}	25.35±1.12
Nov	108^{b}	6.88	18	11	79^{ns}	23.63±1.40
Dec	140^{b}	8.92	54	49	37^{ns}	23.73±1.3
Jan	117^{b}	7.46	32	38	47^{ns}	22.68±1.31
Feb	111^{b}	7.07	41	24	46^{ns}	21.85±1.12
Mar	167^{b}	10.64	120	33	14^{ns}	21.88±1.13
Apr	152^{d}	9.69	60	47	45^{ns}	31.05±1.10
May	130^{a}	8.29	35	48	47^{ns}	18.08±1.04
Jun	97^{c,d}	6.18	12	37	48^{ns}	28.09±1.28
Jul	111^{b}	7.07	42	44	25^{ns}	24.34±1.33
Total	**1569**	**100**	**635**	**430**	**504^{ns}**	**25.01±0.345**

^{ns} = Means were not significantly different (p>0.5) by using t-Test.

^{a,b,c,d} denote significantly different values in a column at p < 0.05 by one-way ANOVA and Duncan's Multiple Range Test

Discussion

The inland freshwater in Nigeria constitutes about 12.4% of the total surface area (Olaosebikan and Raji, 2004; Ekpo *et al*., 2012). According to Idoho-Umeh (2003) and Olaosibikan and Raji (2004), inland waters contain the richest collection of fish in West Africa. Nigeria inland water bodies are primarily utilized for fishing by fishers of which the greatest part is artisanal in nature (Abiodun *et al*., 2005). Nigerian freshwaters, with over 270 fish species, are the richest in fish diversity in West Africa (Tobor, 1992). Confirming the fact, the species composition in this study constituted a total of fifty species, seven genera, nine orders, twenty-one families and 1,569 individuals; mainly of euryhaline species of the families: Sciaenidae, Clupeidae, Carangidae, Scombridae, Bothidae and Gerreidae. These were also the dominant families recorded by Olopade *et al*., 2017), Ekpo *et al*., (2012) and Oboh (2013) who stated that species of the aforementioned families are perpetually found in coastal waters, command market values and are also regularly hunted by the local fishers for commercial purpose. Olopade *et al.,* (2017) and Nkuene (2020) postulated that marine fish species

dominant the estuarine ecosystems are high abundance.

Families' abundance of the fish species sampled revealed that the family Sciaenidae was highest (70.20 %), followed by Clupeidae (70.00%), Carangidae (20.20%), Scombridae (20.10%), Mugilidae (20.00%) while Lobotidae and Soleidae were the least with (0.01%) each. Comparing this finding with other works in the Niger Delta, it records high fish species composition and abundance: Meyer and Ikomi (2012) recorded 35 species belonging to 24 families from River Orogodo in Delta State, Akpan (2013) reported 26 species belonging to 14 families from Uta-Ewa Creek in Akwa-Ibom State, Opel and Paul (2017) documented 26 species belonging to 22 families in Cross River in Cross River State, Olopade *et al.,* (2017) reported 25 species belonging to 18 families from Bonny River in Rivers State and Nkuene (2020) reported 42 species belonging to 23 families in Luubara Creek from Rivers State while Ekpo and Udoh (2013) sampled 1,278 individuals from 8 orders, 22 families, 35 genera and 49 species in lower Cross River floodplain. Dienye and Olopade (2018) obtained 1,541 specimens of 26 fish species and representing 11 families in New Calabar River.

However, reports from other waterbodies in the same climatic environment have presented higher species compositions. For instance, Offem *et al*., (2009) caught 14,466 fish representing 46 species belonging to 28 genera from 16 families in Cross River inlands wetlands. Onuoha *et al*., (2012) sampled 552 fish specimens belonging to 4 orders, 7 families, 14 genera and 26 species in Ntak Inyang Stream; Ekpo *et al*., (2012) opined 136 species belonging to 33 families in Nwaniba in Akwa Ibom State. The variations in the number of species fish identified in studies could be attributed to the sampling methods, duration of sampling and topography of the aquatic systems (Olopade *et al.,* 2017), number of researchers, sampling intensity, season, among other factors.

Spatial variability showed a non-progressive abundance of station A having the highest abundance of 635 individuals (40.47%) whereas the least was seen in station C (504 individuals; 32.12%); however, station B was recorded 430 individuals (27.41%). Such findings have been reported of some coastal waters:

Monthly means were statistically different at $p<0.05$ and were separated into five groups (Table 2). Temporal variations revealed that highest abundance was in March (167 specimens; 10.64%) (21.88±1.13), followed October (157 specimens; 10.00%) (25.35±1.12), August (28.01±0.74) and April (31.05±1.10) (152 specimens; 9.69%) each, December (140 specimens; 8.92%) (23.73±1.34), and May (130 specimens; 8.29) (18.08±1.04) while November recorded the least abundance (108 specimens; 6.88%) (23.63±1.40) (Table 2).

In unpolluted systems, ecological indicators like fish display discrete arrangement or pattern downstream with the number of species tending to increase progressively downstream (Giller and Malmqvist, 2002, Vannote *et al.,* 1980). However, the observed trends/patterns in this present study deviate remarkably from those previously established. Such deviations could be attributed to anthropogenic perturbations in STN 2 which alter the ecosystem stability and cause a shift in the longitudinal pattern downstream.

However, Fagade and Olaniyan (1974) opined that the relative environmental stability, water-flow and improved light penetration resulting in increased photosynthetic activities and plankton production could be responsible for seasonal variation in fish catch. The trend of seasonal variation can also be attributed to migration for several reasons in response to biotic and abiotic situations (Ibim and Bongilli, 2018). Onwuteaka (2015) reported that in the Niger Delta a major challenge for river and stream fish ecologists is the identification of the mechanisms and processes responsible for fish composition in relation to biotic and abiotic factors. Ibim and

Bongilli (2018) observed that the dry season catch was significantly different from the period of the rainy season the Sombreiro River, where eight species were unavailable during the wet season and attributed this variability to salinity.

Conclusion

Generally, most of the species caught were not undersized and competed favorably with other studies in other river ecosystems within the region of southern Nigeria. The species richness and diversity of the creek is unique but the species composition of the creek is influence by environmental factors. Moreover, majority of the species are in good condition and grow very fast but judging from size composition, majority of species are caught at a smaller size range of 10-12 cm. Therefore, there is the need to put up an adequate and appropriate sustainable management measures in place to safe-guide the fin-fish fishery of the Kono creek.

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Mortality Rate Of Most Common Fish Species In Lower Cross River Estuary, Nigeria

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Abstract: *A pooled sample of fish species were randomly collected for 12 consecutive months (February, 2018 to January, 2019) from landings of both artisanal and unskilled fishers at the fishing terminal (Ibaka) of the Lower Cross River. The dominant individuals numerically were Pseudotolithus elongatus (12.99%), Ethmalosa fimbriata (11.63%) and Pellonula leonensis (11.11%). The frequency data was analysed using FiSAT software to evaluate mortality coefficients of four (4) most common fish species (Pseudotolithus elongatus, Liza falcipinnis, Ethmalosa fimbriata and Chrysichthys nigrodigitatus) in the estuary. The current exploitation rate (E_{max}) of 0.38, 0.24, 0.22, 0.26 were recorded for P. elongatus, L. falcipinnis, E. fimbriata and C. nigrodigitatus respectively. The result of the stock assessment revealed that the species are lightly exploited. Therefore, to ensure sustainable management of fishery resources, there is need to maintain the regulation of fishing activity and enforcement of management strategies to avoid over exploitation of the resources and the possible collapse of the fishery.*

Keywords: Lower Cross River Estuary, Nigeria, mortality, most common fish species

CITATION:

Okon, A. O., Udoinyang, E. P., Jackson, A. E. and Nta, A. I. (2023). Mortality Rate of Most Common Fish Species in Lower Cross River Estuary, Nigeria. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 209-212

Introduction:

Mortality (Z) is the total death in a population. It is divided into two categories namely: Natural mortality (M) (death caused by other factors other than fishing) and fishing mortality (F) (Okon, 2018). In fishery management, mortality coefficients come into play when optimum levels of efforts are to be set. Causes of fish mortality include oil pollution, predation, disease, both legal and illegal fishing activities and environmental changes (Greenfacts, 2006).

The growing population densities and alarming unemployment rate in Nigeria have forced many people into fishing thereby increasing pressure on inland and coastal fish resources (Opeh and Paul, 2017). As fishing effort increases, fish fauna assemblages are significantly impacted by continuously eliminating the larger individuals and species from the multispecies communities and replacing them with smaller ones (Welcomme, 2003). Consequently, these smaller individuals are more susceptible to poor water quality as posed by different anthropogenic activities that take place within the coastal region (Asuquo and Udoh, 2002).

Tobor (1991) reported that the value of natural mortality (M) for majority of the Gulf of Guinea fish stocks range from 0.5-1.00, and that a value of 0.7 was a good estimate for natural mortality. Capture fisheries worldwide is

undergoing stock depletion that has made management of capture fisheries and urgent need (Greenfacts, 2006).

Studies of mortality parameters of commercially important and the most common species in lower Cross River are scanty. This is one of the first of this kind of studies in the area.

MATERIALS AND METHODS

Study Area

Lower Cross River estuary in Ibaka, Nigeria lies approximately between latitude 4^{o} and 8^{o}N and longitude 7^{o}30 and 10^{o}E in the southern part of Nigeria. The Cross River Estuary covers an area of about 54,000 km^2 (Akpan and Ofem, 1993) and extends from Mbo, Oron LGAs in Akwa Ibom State to Odukpani, Calabar South and Akpabuyo, LGAs in Cross River State. The estuary receives inflow from five rivers (Cross River, Great Kwa, Kpayafe, Mbo and Calabar Rivers) and finally discharges into the ocean at one drowned river mouth. The common activity across the entire stretch of the estuary is fishing. The area is defined as the coastal zone lying between the East and West points, off the Atlantic Ocean (Eyo and Awom, 2016).

Sample Collection

Fish samples were collected from the artisanal fishers at the fishing terminals daily. Eleven fish species were randomly selected from (5) canoes that arrive daily, twice a month from February to January, 2019.

Estimation of Mortality and Exploitation Rate

Length measurements from the five canoes were done in accordance with Pauly (1983). The measurement with measuring board from the anterior most part of the snout to the tip of the caudal fin formed the total length (TL) in centimeters.

The length measurements were grouped in 1cm class intervals and converted to length frequencies; sequentially arranged for the year and fed into FiSAT (FAO-ICLARM Fish Stock Assessment Tool) for analysis of mortalities after evaluating the asymptotic length (L∞) and the growth coefficient (K).

Total mortality coefficient (Z) was estimated through the catch curve method. The formula integrating the interrelationship between mortality, size and temperature (Pauly, 1983) was used to calculate Natural Mortality (M).

Therefore, Fishing Mortality (F) was thus calculated:

$F = Z – M,$

Where:

F = Fishing Mortality, Z = Total mortality, M = Natural Mortality and Exploitation rate (E) was obtained from;

$E = F/Z$

Where:

F = Fishing mortality, Z = Total mortality

Results

The fish mortality coefficients of Four (4) most common fish species from the Lower Cross River system is presented in Table1. *Liza falcipinnis* had the highest total mortality value of 3.23yr^{-1} and the least mortality value (1.17yr^{-1}) was recorded in *Chrysicthys nigrodigitatus* and the range for total mortality values is 2.06yr^{-1} at 28^{o}C environmental temperature. The current exploitation ratio E for *L. falcipinnis* is (F/Z) = 0.24, indicating that about 24% of the total mortality of the available stock was caused by exploitation. This reveals that the population of *L. falcipinnis* is under pressure.

The fish species that suffered death most (death from both natural and fishing activities) were *L. falicipinnis* followed by *P. elongatus, E. fimbriata* but least in *C. nigriodigitatus.* Death from natural cause was highest in *L. falcipinnis* and lowest in *C. nigrodigitatus*. Death due to fishing activities (F) was highest in P. elongatus and lowest in *C. nigrodigitatus.*

The exploitation ratio (F/Z) of *P. elongatus* is 0.38 indicating that about 38% of the total mortality of the available stock was caused by exploitation. This shows that the population of *P. elongatus* was not under heavy pressure. 0.22 (22%) was the exploitation ratio of E. fimbriata

which is an indication that the population was not under heavy pressure. *C. nigrodigitatus* recorded exploitation ratio of 0.26 which indicate that species population was not under heavy pressure, and that 26% of the total mortality of the available stock was caused by exploitation.

Table 1: Mortality Rates of most common Fish Species from the lower Cross River Estuary

S/N	Fish Species	Z (yr^{-1}) Total Mortality	M (yr^{-1}) Natural Mortality	F(yr^{-1}) Fishing Mortality	E Exploitation Ratio
1.	*P. elongatus*	2.10	1.30	0.80	0.38
2.	*L. falcipinnis*	3.23	2.46	0.77	0.24
3.	*E. fimbriata*	1.86	1.46	0.40	0.22
4.	*C. nigrodigitatus*	1.17	0.87	0.30	0.26

Discussion

The total mortality (Z) value ranges from 1.17year^{-1} (*C. nigrodigitatus*) to 3.23year^{-1} (*L. falcipinnis*). The general high mortality values of the fish species show the effect of ecosystem alteration, environmental degradation, illegal and obnoxious fishing practices and crude oil spills in the Niger Delta on aquatic fauna.

Estimated total natural mortality coefficient (M) ranges from 0.87year^{-1} (*C. nigrodigitatus*) to 2.46year^{-1} (*L. falcipinnis*) (using environmental temperature of 28^{o}C). The values derived for M in this study were lower than those reported by Etim *et al.* (1994); Udoh *et al* (2015) and Bakari *et al* (2019) but higher than that reported by Olapade *et al*. (2019).

Based on Z value, the instantaneous fishing mortality coefficient (F) ranges from 0,30year^{-1} (*C. nigrodigitatus*) to 0.80year^{-1} (*P. elongatus*). The high fishing mortality rate recorded for *P. elongatus* may be as a result of an almost all year-round spawning, the consequent growth and recruitment to fishing and hence the target of all the year-round fishing activities. The exploitation rate (E) which ranges from 0.22 (*E. fimbriata*) to 0.38 (*P. elongatus*) reveals that the population was lightly under pressure. The computed current exploitation rate (E = 0.38, 0.24, 0.22 and 0.26) for *P. elongatus, L. falcipinnis, E. fimbriata* and *C. nigrodigitatus* respectively clearly fall below the predicted value of E_{max} (0.42).

The mortality rate in the study is an indication that increase in certain activities such as the use of speed boat as means of transport, oil spills, gas flaring, urbanization and canalization, can greatly affect the aquatic system and thus increase mortality rates of fishes (Greenfacts, 2006). Those factors can also lead to changes in the physico-chemistry of the aquatic environment causing changes in the metabolic activities of fish species resulting in natural mortality. Also, some factors can affect the turbidity of the water thereby rendering the fishes vulnerable to entanglement or become easy prey to predators and man. In addition, the turbidity can reduce the penetration of light, adversely affecting primary production.

Conclusion

The mortality values in the study at best can only be compared with related species. The mortality rate is an indication that increase in certain activities in the estuary greatly affect the aquatic system and thus increase mortality rates of fishes.

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A Survey Of Avifauna Species In The Town Campus Of University Of Uyo, Nigeria

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Abstract: *This study aimed at assessing the population of avifauna species available in the town campuses of the University of Uyo, Nigeria. The specific objectives of the study included identification of the encountered avifauna species, ascertaining their population density, abundance and other population indices. Two 500m long transect lines, each with a width of 5m on both sides were laid, each per campus to represent all segments of the university. A survey was conducted over a period of three months and data obtained were subjected to ecological indices, descriptive and inferential statistics such as means, bar chart and t-test. Results obtained indicated a total of 1306 avifauna or birds belonging to sixteen bird species were encountered and identified. Pied crow (Corvu albus) was the avifauna species with the highest population density of $3.92*10^{-4}$ individuals per 0.001km^2, followed by the common bulbul, common swift, red eyed turtle dove, the great egret and house martin with $8.25*10^{-4}$, $8.04*10^{-4}$, $5.04*10^{-4}$, $3.92*10^{-4}$ and $3.92*10^{-4}$ individuals per 0.001km^2 respectively, while the common vulture had the least population density of $5.40*10^{-5}$ per 0.001km^2. Nevertheless, a total of 710 and 596 avifauna species were recorded during the morning surveys and late-afternoon survey, although not significantly different from each other ($t = 0.3863$, $df = 1$, $p > 0.05$). The study therefore affirms the presence of some species of avifauna species in the university campuses and recommend the sustainable management and replanting of more trees in the campuses to attract and also conserve the available avifauna species in the university campuses.*

Keywords: Population density, species diversity, avifauna species, University of Uyo

CITATION:
Ukpong, E. E., Jacob, D. E., Amadi, O. N. and Eniang, E. A. (2023). A Survey of Avifauna Species in the Town Campus of University of Uyo, Nigeria. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 198-208

Introduction

The avifauna species are classified as warm-blooded creatures with a backbone, belonging in the phylum Chordata, as well as the class of Aves due to their various plumage (Kwaga *et al*., 2017). They are also considered to be a highly specialised winged creatures that forage across large areas in search of sustenance as well as being effective in evading predation (Alexander, 2015). Avifauna species inhabit various different levels within the food web ranging from consumer to predator (Bideberi, 2013), and their incidences also serve as useful markers of ecosystem quality, pollinators of plants, seed dispersers, and even insect managers (Ramchandra, 2013). Among other reasons, the species are considered a good barometer of global biodiversity because they can colonise and evolve in virtually every part of the world (BirdLife International, 2000). Moreover, due to their value as a conspicuous, attractive, readily recognisable, and being a well-documented and investigated species, they serve as a good barometer of the consequences of a present

land production system (Castillo and Ladio, 2018).

Areas rich in avian can sometimes be utilised as markers of a place's high conservation value and diversity of species (Ijeomah *et al*., 2013). The concept is garnering extensive usage as a way to quantify baseline trends of variety, and judge the success of management practises (Bain, 2013). Complementary value for other species diversity has been demonstrated by the existence of uncommon or threatened taxa, density of organisms, association of certain organisms with significant environments at a location, as well as other avian components (Reyers *et al*., 2000). Hence, conserving avifauna species entails saving their environment and some other species which are linked with that environment. Protecting avian species would also lead to protecting other species such as mammals, amphibians, and invertebrates (Ijeomah *et al*., 2013).

The diversity of avifauna represents one of the main crucial environmental markers to assess the quality of environments. Today, avifauna and other forms of animals are in perilous straits across the globe (Jacob *et al*., 2018; Jacob and Nelson, 2015). Due to persistent pollutants and the delicate state of the ecology in the Niger-delta region, the situation has reached a particularly dire stage (Jacob *et al*., 2015a; 2012; Nelson *et al*., 2013). Avifauna richness had already been diminishing as a result of degradation of wild areas and anthropogenic disruptions (Jacob, 2012). Drops in bird foraging ecology, breeding grounds, and species are primarily attributable to the indiscriminate loss of natural ecosystems by falling brooding forests and forage vegetation for commercialisation of forests and fields (Sorensen *et al*., 2020; Nelson and Jacob, 2017). Occasioned on such issues, there is now an increasing concern regarding conservation of avifauna species. Since the University of Uyo does not keep accurate records of the variety of avian species available in its campuses, it would be extremely difficult to detect the loss of certain avifauna species if they occurred.

To evaluate the effects of anthropogenic activities on the environment and to comprehend the normal patterns of change in avian species, it is critical to track the avifauna species and their environment. Reversing the erosion of species diversity and tracking the risk of extinction requires a rigorous assessment of community patterns and ecosystems. Possible hazards to the avian species can be assessed by surveying and monitoring assessments. Therefore, in order to better understand the avifauna species available in the University of Uyo, the study was carried out. Two campuses of the university were surveyed to determine the avian species richness, density, and diversity.

Methodology

Study Area

The study was conducted in the two town campuses (Main and Annex campuses) of University of Uyo. The two campuses have a total land area of 91.875 hectares (Main campus = 56.956ha, Annex Campus = 34.919ha). Both campuses of the University are situated in Uyo Local Government Area (LGA) of Akwa Ibom State, Nigeria. Uyo LGA lies between latitude 4°33'and 5°33'N and longitude 7°53' and 8°25'E. Uyo LGA is bounded in the East by Ibsikpo Asutan and Nsit Ibom LGAs, Etinan LGA in the South, Abak LGA in the West, while Ikono and Itu LGAs are in the North. The state as a whole witnesses two distinct seasons namely the dry and rainy seasons. The rainy season commences from early March - October, with high precipitation in the month of July, while the dry season starts from November to early February with the peak in January during which the dusty harmattan wind occurs. The mean annual rainfall for the state is 3000mm. Temperature in the state varies between 28°C - 30°C depending on the season, while the relative humidity ranges from 10% - 90% (Jacob and Nelson, 2021).

Method of Data Collection

The data for the study were collected primarily from field survey. The survey was carried out using the line transect method. Line transect method is a sampling method that involves counting the number of individuals or species encountered along the transect line which is randomly place across the habitat to be sample (Jacob et al., 2015a; Jacob, 2012). It is also a fixed path independent of any external influence which may introduce bias during census when the survey is taking place. Consequently, two transect line each of 500m in length and width of 10m (5m on both sides of the transect were laid (one in each campus) and used for the study. The lines were stratified to represent all the various segments in the study area. Consequently, the total sample survey area for the study was $10000m^2 = 1*10^{-3}km^2$

The survey was conducted once in a week in each campus for over a period of three months (July - September), thereby yielding a total of twelve survey days in each campus. Direct counting method was adopted in counting and identifying all the encountered avifauna in the study area. Moreover, the survey was usually conducted in the early and late hours of the day between 6:30 am and 8:00am, and 4:30pm and 6:00pm respectively, once a week in each campus.

The avifauna species were sighted with binoculars and identified through their vocal sounds and physical appearances using Adeyanju *et al*., (2014) field guide handbooks. Further identifications were made by an expert ornithologist engaged in the study. Photographs of some avifauna species were also carried along during the survey to enhance further identification of the species.

The assumptions of the line transect method as stated by Burnham *et al*., (1984) were followed during the survey exercise. The assumptions were:

i. Animals positioned directly over the transect line are not missed. Thus, it is understood that not all animals within the survey area will be detected. Some inevitably are missed and the probability of detection declines with increasing distance from the transect line.
ii. Animals or social group are counted once before they flee, as such none is counted twice. Any behavioural response by the animal to the presence of the observer does not affect sighting distance. The position of the group (bearing and distance) to the transect line is determined before they move away.
iii. The sighting of each animal or group is independent of sighting of other animals or groups.
iv. Species specific behaviour is constant relative to transect. All groups of animals and their signs are distributed at random, with respect to the transect line.
v. The behaviour of groups does not vary with location along the transect line. Behavior of groups is species-typical, that is the response of a group to observers is the same as that of other groups of the same species regardless of group size or composition. Thus, their detectability increased with distance from transect line between the survey sites.

Data Analysis

The encountered avifauna species were sorted into their respective orders and family and their population indices computed accordingly. The population density of the species was computed using the formula;

Population density (D) = encountered frequency / sample area - - (1)

Total population (p) = (encountered frequency / sample area) * Total area - (2)

The Diversity Index of the avifauna species was determined using Shannon Weiner Index (H1) as used by Udoakpan *et al*., (2013).

Diversity Index (H1) = $\Sigma Pi \ln Pi$ - (3)

Where: Pi = Ni/N, Ni – Total number of individuals of species I, N – Total number of individuals of all species, In = Natural log

Species Richness was also calculated using Margalef Index (d) as described by Jacob *et al.*, (2015b)

Species Index (d) = S-1/In N - - (4)

Where: S – Total number of Species, N – Total number of individuals of all species.

The Species evenness was calculated using Pielon Index (E) as described by Jacob *et al*., (2015b)

Pielon Index (E) = H1/InS - - (5)

Where: H1 – Diversity Index, S - Total number of Species

$F_k = \Sigma Y_i/n \; X \; 100$ - - (6)

Where: F_k – frequency, Y_i – incidence of species k in site I, n – number of species sampled

Student t-test was used in ascertaining the mean variation in avifauna species encountered in the early and late hours of the day for the survey period.

Results

i. Density and total population of avifauna species

Results in Table 1 indicates that a total of 16 species of avifauna were recorded in the study area and pied crow (*Corvu albus*) had the highest density of $3.92*10^{-4}$ individuals per $0.001km^2$ and a total population of 3601.50, followed by the common bulbul, common swift, red eyed turtle dove, the great egret and house martin with $8.25*10^{-4}$, $8.04*10^{-4}$, $5.04*10^{-4}$, $3.92*10^{-4}$ and $3.92*10^{-4}$ individuals per $0.001km^2$ respectively and a total population of 7579.69, 7386.75, 4630.50, 3601.50 and 3601.50 respectively. Bush fowl recorded $3.21*10^{-4}$ individuals per $0.001km^2$ (2949.19), cattle egret and African grey hornbill recorded $1.63*10^{-4}$ per $0.001km^2$ (1497.56) respectively. Domestic fowl had $1.33*10^{-4}$ per $0.001km^2$ (1221.94), morning dove had $1.04*10^{-4}$ per $0.001km^2$ (955.50), Speke's weaver had $8.3*10^{-5}$ per $0.001km^2$ (762.56), barn owl had $8.80*10^{-5}$ individuals per $0.001km^2$ (8.8.50), and Senegal caucal had $7.50*10^{-5}$ individuals per $0.001km^2$ (689.06), while the common vulture had the least population density and total population of $5.40*10^{-5}$ and 385.88 respectively

ii. Abundance of avifauna species in the campuses

The results in Table 2 indicate that a total of 1306 avifauna belonging to 16 species were encountered during the survey period. However, pied crow (*Corvu albus*) was the most abundant (312) compared to other available avifauna species, with a relative abundance score of 23.89%. This was followed by the common bulbul, common swift, red eyed turtle dove, the great egret and house martin with 198, 193, 121, 94 and 94 encountered individuals respectively, with relative abundance of 15.16%, 14.78%, 9.26%, 7.19% and 7.19% respectively. Bush fowl were 77 encountered individuals (5.89%), cattle egret and African grey hornbill recorded 39 individuals (2.99%). Domestic fowl had 32 individuals (2.45%), morning dove was 25 (1.91%), Speke's weaver had 20 individuals (1.53%), barn owl had 21 individuals (1.61%) and Senegal caucal had 18 individuals (1.38%), while the common vulture had the least encountered species frequency and relative abundance of 10 and 0.77% respectively.

Species diversity indices for the avifauna species ranged between -0.0373 and -0.3420 (Table 2). As indicated in the table, *Corvu albus* had the highest species diversity index, followed by *Pycnonotus barbatus* (-0.2860)*, Apus apus* (-0.2826)*, Streptopelia semitorquata* (-0.2204)*, Ardea alba (*-0.1894) and *Delichom urbicum (*-0.1894), while *Gypus fulvus* had the least diversity index of -0.0373. In total, the diversity index for all the avifauna species in the study area was -2.3257, indicating a considerable level of species diversity, while the species richness and evenness were 15.8606 and -0.8388 respectively.

Table 1: Density and Total Population of Avifauna Species

S/N	Avifauna species	Encountered frequency	Mean frequency	Population Density	Total Population
1	Great Egret *Ardea AIba*	94	3.92	$3.92*10^{-4}$	3601.50
2	Senegal caucal *Centropus senegalensis*	18	0.75	$7.5*10^{-5}$	689.06
3	Pied crow *Corvu albus*	312	13.00	$13.00*10^{-4}$	11943.75
4	Cattle egret *Bubulcus ibis*	39	1.63	$1.63*10^{-4}$	1497.56
5	African grey hornbill *Tockus nasutus*	39	1.63	$1.63*10^{-4}$	1497.56
6	Speke's weaver *Pioceus spekel*	20	0.83	$8.3*10^{-5}$	762.56
7	Morning dove *Zenaida macroura*	25	1.04	$1.04*10^{-4}$	955.50
8	Common swift *Apus apus*	193	8.04	$8.04*10^{-4}$	7386.75
9	House martin *Delichom urbicum*	94	3.92	$3.92*10^{-4}$	3601.50
10	Domestic fowl *Gallus gallus*	32	1.33	$1.33*10^{-4}$	1221.94
11	Barn owl *Tyto alba*	21	0.88	$8.8*10^{-5}$	808.50
12	African marsh harrier *Circus ranivorus*	13	0.54	$5.4*10^{-5}$	496.13
13	Red eyed turtle dove *Streptopelia semitorquata*	121	5.04	$5.04*10^{-4}$	4630.50
14	Common vulture *Gypus fulvus*	10	0.42	$4.2*10^{-5}$	385.88
15	Common bulbul *Pycnonotus barbatus*	198	8.25	$8.25*10^{-4}$	7579.69
16	Bush fowl *Francolinus bicalcaratus*	77	3.21	$3.21*10^{-4}$	2949.19

iii. Variation in avifauna encountered between morning and evening surveys

The survey data for the frequency of avifauna species encountered during the morning surveys and late in the afternoon surveys is presented in Table 3. A total of 710 avifauna species accounting for 54.36% of the total number of species (1306) encountered during the survey was recorded during the morning surveys, while 596 representing 45.64% was recorded in the late-afternoon survey. Statistically, despite the higher number of avifauna species encountered during the morning survey against the late-afternoon survey, there was no significant difference between them ($t = 0.3863$, $df = 1$, $p > 0.05$). A further analysis indicates that the rate of species encounter in the morning was higher in nine of the species compared to six in the late-afternoon surveys. The widest margin in terms of number of species encountered between the

morning and late evening surveys was *Apus apus,* with 73 individual species. This was followed by Corvu albus with 64 individuals, *Delichom urbicum,* 52 individuals and *Francolinus bicalcaratus* with 37. Other individual variations ranged between 4 and 33., while there was similar number of *Pycnonotus barbatus* species encountered in both the morning and late-afternoon surveys

Table 2: Relative abundance of avifauna species in University of Uyo town campuses

S/N	Avifauna species	Encountered frequency	Relative abundance (%)	Diversity index
1	Great Egret *Ardea aIba*	94	7.20	-0.1894
2	Senegal caucal *Centropus senegalensis*	18	1.38	-0.0591
3	Pied crow *Corvu albus*	312	23.89	-0.3420
4	Cattle egret *Bubulcus ibis*	39	2.99	-0.1049
5	African grey hornbill *Tockus nasutus*	39	2.99	-0.1049
6	Speke's weaver *Pioceus spekel*	20	1.53	-0.0640
7	Morning dove *Zenaida macroura*	25	1.91	-0.0757
8	Common swift *Apus apus*	193	14.78	-0.2826
9	House martin *Delichom urbicum*	94	7.20	-0.1894
10	Domestic fowl *Gallus gallus*	32	2.45	-0.0909
11	Barn owl *Tyto alba*	21	1.61	-0.0664
12	African marsh harrier *Circus ranivorus*	13	1.00	-0.0459
13	Red eyed turtle dove *Streptopelia semitorquata*	121	9.26	-0.2204
14	Common vulture *Gypus fulvus*	10	0.77	-0.0373
15	Common bulbul *Pycnonotus barbatus*	198	15.16	-0.2860
16	Bush fowl *Francolinus bicalcaratus*	77	5.90	-0.1669
Total		**1306**	**100.00**	**-2.3257**

Avifauna species richness = 15.8606, species eevenness = -0.8388

Table 3: Variation in avifauna encountered between morning and evening surveys

S/N	Avifauna species	Morning (%)	Evening (%)	Total (%)
1	Great Egret *Ardea alba*	49(52.13)	45(47.87)	94(100)
2	Senegal caucal *Centropus senegalensis*	11(61.11)	7(38.89)	18(100)
3	Pied crow *Corvu albus*	188(60.26)	124(39.74)	312(100)
4	Cattle egret *Bubulcus ibis*	3(7.69)	36(992.31)	39(100)
5	African grey hornbill *Tockus nasutus*	15(38.46)	24(61.54)	39(100)
6	Speke's weaver *Pioceus spekel*	11(55.00)	9(45.00)	20(100)
7	Morning dove *Zenaida macroura*	19(76.00)	6(24.00)	25(100)
8	Common swift *Apus apus*	135(69.95)	58(30.05)	193(100)
9	House martin *Delichom urbicum*	73(77.66)	21(22.34)	94(100)
10	Domestic fowl *Gallus gallus*	21(65.63)	11(34.38)	32(100)
11	Barn owl *Tyto alba*	2(9.52)	19(90.48)	21(100)
12	African marsh harrier *Circus ranivorus*	8(61.54)	5(38.46)	13(100)
13	Red eyed turtle dove *Streptopelia semitorquata*	53(43.80)	68(56.20)	121(100)
14	Common vulture *Gypus fulvus*	3(30.00)	7(70.00)	10(100)
15	Common bulbul *Pycnonotus barbatus*	99(50.00)	99(50.00)	198(100)
16	Bush fowl *Francolinus bicalcaratus*	20(25.97)	57(74.03)	77(100)
Total		**710(54.36)**	**596(45.64)**	**1306 (100)**

Discussion

The presence of sixteen species of avifauna in the University of Uyo town campuses is an indication of the relatively safe habitat for the available species. This is in accordance with the report of Morelli *et al*. (2022), who asserted that the presence of avifauna species in an area serves as one of the important indicators of the safety of the environment. Their presence speaks volume of the environment as to whether all is well or there is something amiss (Lindenmayer *et al*., 2015). They can also be used as a surrogate indicator of species richness or other indicators of biodiversity in areas where they are present (Morelli *et al*., 2022). The presence of fruits and flowers in a location would certainly attract nectar and seed eating avifauna species, while the presence of carcases

will invariably attract scavengers such as the vultures to the location. However, the number of avifauna species recorded in the study area is less than 28 and 44 species recorded in 2011 and 2018 by Abduljalil (2011) and Zara *et al*., (2021) in Usmanu Danfodiyo University, Sokoto. The variation in avifauna species between the two campuses could be attributed to location, vegetation and size of the campuses.

Consequently, the high population of *Corvus albus, Pycnonotus barbatus, Apus apus, Streptopelia semitorquata, Ardea alba* and *Delichom urbicum* in the study area could be attributed to the presence of insects, nectar and fruits in the area. These species are fruits, nectar and seed eaters; hence they are attracted to the location. This assertion is in line with the report of Montague-Drake *et al*., (2011), which contend that the abundance of food is a principal determinant of the distribution and abundance of fauna species. However, the low abundance and population density of *Gypus fulvus* in the study area could be attributed to the scarcity of its food as the avifauna species is a gregarious obligatory scavenger that feeds mainly on carcasses of animals. This result agrees with the observation of Ijeomah *et al*., (2013), who reported that the presence of carcasses in an area would always attract avifauna species of the Accipitridae family. Nevertheless, the preferred food by the Accipitridae family was not abundant in the study area. In addition, the population of *Gypus fulvus* in the study area could have been affected by the level of anthropogenic activities which is inevitable in the two campuses of the university. This includes noises from vehicles, people and other human activities.

Habitat destruction is another factor that could be blamed for the availability of only sixteen avifauna species, low population density and abundance of avifauna species in the study area. The forest area in the campuses is cleared on a continuous basis to make way for new buildings and infrastructures in the university campuses, thereby changing the composition and structure of the university environment. This observation is in line with the study outcome of Ijeomah *et al*., (2013), who contended that there were more avifauna species in the Choba campus of the University of Port Harcourt compared to those of Abuja and Delta campuses which have large open spaces and few tree species. Whereas in the Choba campus of the university, there are more number of trees closely knitted to give it a good resemblance of a forest area in the campus thereby attracting more avifauna species to the university campus. Vegetation types and structure affects avifauna community ecological integrity and characterization because their foraging ecosystem is influenced by factors such as vegetation structure, height, and forms (Pulido-Santacruz and Renjifo, 2011). Additionally, some species preferentially forage on particular plant species.

Season, weather and climate of the study area is another factor that could be assumed to have affected the population density and relative abundance of avifauna species in the University Campus. This notion is consistent with the findings of Mainwaring *et al*., (2021), who claimed that even the little variations in meteorological conditions can alter practically every area of bird ecology. Relatively brief or local variations in temperature, precipitation, and breeze can have a significant impact on individual behaviors, life cycle, metabolism, and appearance, with population and species-level repercussions (Wiley and Ridley, 2016).

Time of survey had an impact on the frequency of avifauna species encountered in the study area, although not significantly different. Nevertheless, the rate of avifauna species encountered in the early hours of the day was higher than that of the late afternoon. This could be attributed to the feeding habit of the avifauna species. Surprisingly, these findings support the notion that mornings are the ideal time to see avian species. According to Morelli *et*

al., (2022), the morning period is the ideal time for researchers to watch bird species that graze on grains and insects in open areas such as fields and lawns. In contrast, species that live in various settings lay less emphasis on this time of day. As a result, only species that feed on grains and/or insects can exhibit a significant and highly important midday trend across a variety of habitat types (Wiens *et al*., 2012). It is hypothesised that bugs are more active throughout the day when temperatures are high; fluctuations in detection rate could be driven by avian species imitating the habits of their food supply (Eotvos *et al*., 2020).

Conclusion

The study shows that despite the unsustainable habitat of the university campus for birds, , there is a number of avifauna species still present in the university campuses. Hence, there is need for the avifauna species to be among other ecological indices to be considered when the school is embarking on infrastructural development, to ensure their sustainability. Therefore, based on the outcome of this study, the following recommendations are made;

i. More trees should be planted in the university campuses to attract and sustain the available avifauna species in the university campuses.

ii. Similar study should be extended to the main campus of the university to ascertain the available avifauna species and their population for effective monitoring and conservation measures to be adopted.

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Aquaculture Species Biodiversity: Relevance Of The Introduction Of Non-Native Species For Aquaculture Development In Africa.

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Abstract : *This study identifies the five major causal factors (Drivers, Pressures, State, Impacts and Response, DPSIR) to the phenomenal growth and increase in aquaculture production in recent times with about 600 species contributing to this. Aquaculture provides a number of socio-economic benefits, including food provision, improved nutrition and health, generation of income and employment, diversification of primary products, and increased trade earnings through the export of high-value products. Particularly, cultured seafood can reduce pressure on overexploited wild stocks, stocked organisms may enhance depleted stocks, aquaculture often boosts natural production and species diversity, and employment in aquaculture may replace more destructive resource uses. For uninterrupted continual flow of these enormous socio-economic goods, proper management of species biodiversity at genetic, population, species, and community and ecosystem levels is indispensable. The global aquaculture industry cannot afford loss of biodiversity; such as is being experienced in most natural ecosystems. Within the aquaculture industry it is increasingly becoming difficult to obtain or maintain pure breeds or strains in captivity or to locate and collect genetic materials from healthy or relatively undisturbed wild populations. Although introduced species (positively) contribute over 10% of global aquaculture production; yet they also exert negative impacts and threaten aquatic biodiversity by: habitat alterations; trophic alterations; gene pool alterations; alterations to communities and competition with native species for food and space; introduced diseases; changes in species diversity; alteration in the health of native species; and impacts to water quality. Unfortunately, FAO database capture only about 38.7% of such introductions owing to under-reporting. Asia recently achieved introduced a low-priced freshwater catfish, Pangasius species, from Viet Nam., into the international fish trade with wide acceptance. With adequate incentives, strategic engagement of private sector aquafarmers, proper attention to research, protecting and propagating germplasms of indigenous species, vis-a-viz the introduction of exotic species, development of new strains, and best management practices, Africa could boost aquaculture production, aquaculture biodiversity and promote her native species to international fish trade and prominence. Moreover, precautionary approach should be adopted in the introduction of non-native species unless robust risk assessment is done, the outcome of which should form the basis for issuance of import permits.*

Keywords: Blue economy, disease outbreak, DPSIR framework, risk assessment, trans-boundary transfers.

CITATION:

Udoh, J. P. and Otoh, A. J. (2023). Aquaculture Species Biodiversity: Relevance of the Introduction of Non-Native Species for Aquaculture Development in Africa. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 168-197

Introduction

A greater size of food item in the diet and nutrition of people in the world is fish, particularly, people in the developing world. The traditional sources of fish production and supply world-wide are water resources including oceans, seas and inland rivers, lakes and wetland. These sources of wild stocks have invariably been overexploited, with little or no room for expansion. Aquaculture making up for the shortfall of additional 30–40 million tonnes of food fish production needed globally. Aquaculture is the farming of aquatic species at any trophic level for domestic consumption, sport or export. The five main pressures on, causal factors and drivers of change to biodiversity (direct and indirect) in the context of the phenomenal growth of aquaculture around the world were identified in Udoh (2016) using the Drivers, Pressures, State, Impacts and Response (DPSIR) framework (Figure 1). In the Driving Force-Pressure-State-Impact-Response (DPSIR) framework (Cochrane and Garcia, 2009), the driving force corresponds to drivers generating pressures (e.g. demand for food, investments) and impact corresponds to measures of changes through time. Its direct applications to fisheries are scarce. Cochrane and Garcia (2009) noted that institutional response indicators measure the capacity of a management system (in human, institutional and financial terms) to reach objectives and are guided by governance principles such as openness, participation, accountability, effectiveness, coherence, subsidiarity and proportionality. The **Drivers** in the context of this study include growing world population; declining, overexploited and depleted natural or wild stocks; expansion of aquaculture and profit maximization. Other important drivers of aquaculture diversification include market forces, consumer demand, competitive advantage, opportunities, reduced availability of a species in the wild, location or resource availability, diseases, government policies, social pressure and climate change (Harvey *et al.,* 2017). The **Pressures** include demand for food, ecosystem degradation, alteration and/or removal; climate change; pollution; aquaculture expansion and intensification; and conflicts among the multiple resource users of common property. The present **State** of aquaculture is characterized by: hi-tech applications/technological advancement; 541 aquaculture species in use; high cost of input; widespread adoption of aquaculture; and resource scarcity. Aquaculture **Impacts** include: increased fish production; food security and biosecurity issues; wealth creation and employment generation; reduced access to market; spread of diseases; ecosystem damage; improved livelihoods and wellbeing of people involved in aquaculture. Hence, institutional **Responses** include: fish stock assessment; Fisheries/Aquaculture governance; stakeholder involvement; creation of regulatory authorities; food safety concerns; best management practices; gender representation, and aquaculture certification, which ultimately is incorporated into aquaculture development plans from the local level upwards (Figure 1).

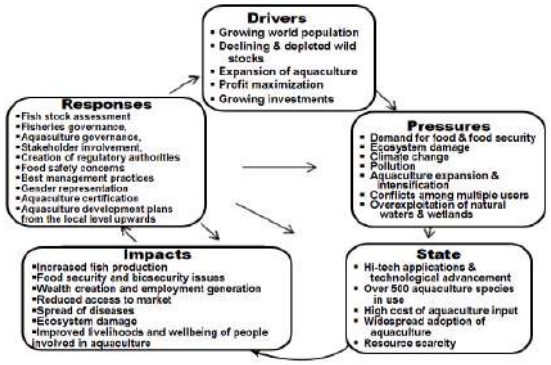

Fig. 1: Cause-effect analysis using DPSIR framework in the context of the phenomenal growth of aquaculture worldwide Source: (Udoh, 2016)

This paper examines current situation of aquaculture in the context of diverse species exploited in aquaculture systems, the

introduction of non-native species and the rationale and relevance of these activities for aquaculture development in Africa.

Arguments for and against Aquaculture

Aquaculture operations could be land-based systems (such as ponds, tanks, raceways, and water flow-through and recirculating systems) or water-based systems (netpens, cages, ocean ranching, longline culture, and bottom culture). The global boom in aquaculture operations indirectly connotes positive or negative consequences. It is a corollary of negative impacts on biodiversity, and exacerbating overexploitation of wild stocks from natural fisheries through damages to natural ecosystems, land use, effluent discharge, effects on wild populations, introduction of alien species, loss of biodiversity, among others. On the other hand, Stotz (2000) is of the opinion that aquaculture could positively alleviate pressure on wild fish stocks. Both opinions conform to the fact and are reasonably accepted within limited sets of management; and conform to United Nations Sustainable Development Goal 14 (on fisheries and aquaculture sustainability). The management of aquaculture systems and not aquaculture in itself, has been identified (Copp *et al.,* 2008) as the key, defining the relationship and interaction of aquaculture with the environment and biodiversity. For example, issues of water pollution are related to overfeeding, direct release of farm effluents to adjoining/feeder water bodies, etc. These are largely management issues which could be treated *in situ* if best management practices are employed. Further development and management issues in aquaculture include deployment of new tools in analysing introduction and establishment of new species, species invasiveness, and then generate a risk assessment (Campbell, 2005, 2006).

Aquaculture provides socio-economic benefits such as food provision, improved nutrition and health, generation of income and employment, diversification of primary products, and increased trade earnings through the export of high-value products. Global fish production is estimated to have reached about 179 million tonnes in 2018; out of which 156 million tonnes were used for human consumption (i.e., about 20.5 kg is supplied per capita per annum) (FAO, 2020). The contribution of aquaculture to total global fish production increased from about 5% in 1980 to about 30% as at 2009, 42.2% in 2014 (FAO, 2014) and 46% of the total production in 2018. About 52% of total fish produced was for human consumption. Global aquaculture production has been on the increase, averaging 5.3 percent increase per year in the period 2001–2018; resulting in an all-time record high of 114.5 million tonnes in live weight in 2018 (valued at USD 263.6 billion). This consisted of aquatic animals (82.1 million tonnes), aquatic algae (32.4 million tonnes) and ornamental seashells and pearls (26 000 tonnes). The farmed aquatic animals consisted mainly finfish (54.3 million tonnes). Fed aquaculture production (57 million tonnes) outpaced that of the non-fed subsector in world aquaculture. Also, in 2018, an estimated 59.51 million people were engaged in the primary sector of fisheries (38.98 million) and aquaculture (20.53 million). Globally 19% of the total work force in aquaculture were women; larger than that in fisheries (12%). Globally, fish provided about 3.3 billion people with almost 20 percent of the average per capita intake of animal protein; lowest per capita fish consumption was in Africa, where it peaked at 10.5 kg in 2014 and then declined to 9.9 kg in 2017 (FAO, 2020).

Aquaculture also provides environmental benefits such as supporting stocking and release of hatchery-reared organisms (aquaculture-based fisheries), countering nutrient and organic enrichment in eutrophic waters from the culture of some mollusk and seaweed species (fisheries-based aquaculture), and prevention and control of aquatic pollution through good water quality management.

The negative impact of aquaculture operations in freshwater, estuarine, and marine ecosystems include their adverse effects on habitat of native fish and shellfish species. Such impact includes the release of aquaculture effluent directly or indirectly into the environment; contingent upon the species cultured, the type and size of the operation, and the environmental characteristics of the site. Intensive cage and floating netpen systems typically have a greater impact because they release of aquaculture effluent directly into the environment. Pond and tank systems are less harmful to the environment because waste products are released in short cycles during cleaning and harvesting activities rather than continuously into the environment. The relative impact of finfish and shellfish aquaculture differs depending on the foraging behaviour of the species. Use of feed inputs, in one form or the other, impacts on biodiversity and environmental integrity, in all forms of aquaculture. Finfish require the addition of a large amount of feed into the ecosystem, which can result in environmental impacts from the introduction of the feed, but also from the depletion of species harvested to provide the feed. Bivalves are filter feeders and typically do not require food additives; however, faecal deposition can result in benthic and pelagic habitat impacts, changes in trophic structure (Kaspar *et al.*, 1985; Grant *et al.*, 1995), and nutrient and phytoplankton depletion (Dankers and Zuidema, 1995). Beveridge *et al.* (1994) and Diana (2009), further suggest other negative impacts of aquaculture on biodiversity to include over-use of non-renewable resources, e.g. land, water; use of chemicals in aquaculture as well as waste/effluent discharge with consequent negative impacts; and others.

Aquaculture Species and Species Biodiversity

Biodiversity—or biological diversity—is the sum of all the genetics and life forms of populations, species, and communities that exist, their interactions and the ecosystems they form. Biodiversity affects the capacity of living systems to respond to changes in the environment, and is essential for providing goods (such as food, fodder, fibre, fuel, pharmaceuticals and many other products) and services that contribute to the wellbeing of all the inhabitants of our planet or ecosystems (Costanza, 1997; Hooper, 2005). Knowledge of fish biodiversity is increasing, though gaps exist. Much knowledge is still desired in the exploitation and conservation status of aquaculture fish species. Mobilizing biodiversity resources ensures visibility and socio-economic sustainability of communities that derive livelihood and nutritional security from them in line with SDG Goal 14.

Although there are approximately 48,170 recognized living vertebrate species, some authors estimate between 30,000 and 35,000 are fish species, while Nelson (1994), estimate 28,600 valid fish species (based on FishBase, the largest database on fishes). FAO (2012) estimates show that the number of aquatic food fish and algae species are employed in aquaculture production worldwide increased from 310 in 2008 (FAO, 2010) to over 514 in 2010 (FAO, 2012), including 327 finfishes (5 hybrids), 102 molluscs, 62 crustaceans, 6 amphibians and reptiles, 9 aquatic invertebrates and 35 algae. The dominant species cultured worldwide are shellfishes and herbivorous and omnivorous pond fish species which feed low in the food chain and are easier to culture through enrichment of the culture media by fertilization (Goldburg *et al.*, 2001, 2003). The dominant freshwater fish species in aquaculture production are carp (*Cyprinus carpio*), tilapia (*Oreochromis mossambicus*, and *O. niloticus*) and pangasius catfish, in order of magnitude. Coastal aquaculture primarily comprises whiteleg and, to a lesser extent, tiger shrimp, oyster, scallop and mussels, with Atlantic salmon (*Salmo salar*) as the leading intensively farmed marine fish (Bostock *et al.,* 2010). The focus of aquaculture also varies between developing and

developed countries: while the former have a thriving aquaculture production of lower trophic level species, the latter focus essentially on the culture of high value, high trophic level carnivorous species. Equally, their production systems vary: subsistence/semi-intensive compared to intensive/recirculatory systems, respectively. Table 1 shows species used (or introduced) in commercial aquaculture in African countries.

Almost 10% of global aquaculture production came from introduced species (Garibaldi and Bartley, 1998). FAO (2012) lists successful internationally introduced species for finfishes to include tilapias from Africa (especially Nile tilapia), Chinese carps (silver carp, bighead carp and grass carp), Atlantic salmon (*Salmo salar*), *Pangasius* catfishes (*Pangasius* spp.), largemouth black bass (*Micropterus salmoides*), turbot (*Scophthalmus maximus*), piarapatinga (*Piaractus brachypomus*), pacu (*Piaractus mesopotamicus*), and rainbow trout (*Oncorhynchus mykiss*). Red swamp crayfish (*Procambarus clarkii*) from North America and giant river prawn (*Macrobrachium rosenbergii*) from South and Southeast Asia have also become important for freshwater culture in countries foreign to these species. A significant part of the global production of marine molluscs, particularly in Europe and America, relies on the widely introduced Japanese carpet shell (*Ruditapes philippinarum*, also known as Manila clam) and Pacific cupped oyster (*Crassostrea gigas*). China now produces large quantities of Atlantic bay scallop (*Argopecten irradians*) and Yesso scallop (*Patinopecten yessoensis*).

A considerable number of hybrids, most notably of finfish, are used in aquaculture, especially in countries with a relatively high level of development in aquaculture technologies. Commercially farmed hybrids include: sturgeons (such as beluga *Huso huso* x starlet sturgeon *Acipenser ruthenus* known as "bester") in Asia and Europe; *Carassius* spp., snakeheads and groupers in China; characins in South America; and freshwater catfishes (*Clarias gariepinus* x *Heterobrachus longifilis*) in Africa and Europe. The culture of hybrid tilapias is particularly common around the world. The hybrid of *Oreochrom aureus* x *O. niloticus* (with a high percentage of male offspring) is farmed in China, and the saline-resistant hybrid of *O. niloticus* x *O. mossambicus* in the Philippines (FAO, 2012).

The diversity and production of major species or species group from aquaculture indicate the top five **finfish** species farmed are: grass carp, *Ctenopharyngodon idellus* (10.5%), silver carp, *Hypophthalmichthys molitrix* (8.8), Nile tilapia, *Oreochromis niloticus* (8.3%), Common carp, *Cyprinus carpio* (7.7%) and the Bighead carp, *Hypophthalmichthys nobilis* (5.8%). The top five finfish hybrids that have gained prominence in national production statistics by FAO estimates, are blue and Nile tilapia hybrid (*Oreochrom aureus* x *O. niloticus*) in China and in Panama, *Clarias* catfish hybrid (*Clarias gariepinus* x *C. microcephalus*) in Thailand, "tambacu" hybrid (*Piaractus mesopotamicus* x *Colossoma macropomum*) in Brazil, "tambatinga" hybrid (*Colossoma macropomum* x *Piaractus brachypomus*) in Brazil and striped bass hybrid (*Morone chrysops* x *M. saxatilis*) in the United States of America, Italy and Israel (FAO, 2012). In terms of global trade, the top five species that contribute largest single commodity in value terms (of the total value of internationally traded fishery products in 2010) are **Shrimp** (15%) with Thailand, China and Viet Nam being the major exporting countries and the United

Table 1: Principal exotic and non-endemic cultivable species deliberately introduced into Africa and other countries

S/N	Family/Species	Receiving Country	Reason for introduction	Remarks
1	**Salmonidae** *Salmo gardneri* (rainbow trout)	Zimbabwe, Kenya	Sport fishing in fish farms	Successful. (represented 33% of fish population in 1982)
2	*Salmo hucho L.*	Morocco, Lesotho, Kenya, Tunisia, Uganda, Sudan, Ethiopia, Morocco Swaziland, and	Experimental, for sport fishing, stocking natural waters (mountain streams), Rivers, Dams	*Salmo trutta trutta* was successful in Kenya Other salmonids introduced were not successful; because they're cold-water fish; but were established in Rivers Nagishot, Kitiri, Danka and Web in Ethiopia
3	*Salmo irideus*	Madagascar, Ethiopia, and Swaziland	For sport fishing in Rivers, Dams	
4	*Oncorynchus tschwytscha*			
5	*Salmo trutta*			
6	*Salmo trutta macrostigma*	Morocco		
7	*Salmo trutta trutta*	Kenya		
8	*Salmo letnica*	Morocco		
9	*Salvelinus sp.*			
10	*Esox mosquinongy*			
11	**Centrarchidae** *Eupomotis gibbosus*	Morocco, Congo, Swaziland, Zambia & Madagascar	Fish for forage (for black bass feeding)	Introduced by private enterprise
12	*Lepomis macrochirus*			
13	*Lepomis microlophus*	Mauritius, Morocco	Fish for forage, For sport fishing; Tilapia control	Introduced by private enterprise, Did not spawn in ponds, Unsuccessful in some cases; and stocked together with
14	*Micropterus dolomieu*	Swaziland		
15	*Micropterus punctulatus*	Swaziland		
16	*Micropterus salmonids* (black bass)	Kenya, Congo, Morocco, Egypt, Swaziland, Tunisia, Mauritius, Uganda, Madagascar, Cameroon,		
		Mexico	Increase fish production	Destroyed highly-prized pescado blanc fishery
		Nigeria	Aquaculture	Not successful
17	*Morone saxatilis*	South Africa and Morocco	Fish for forage	Not successful
18	*Pomoxis annularis*			
19	*Pomoxis nigromaculatus*			
20	**Cyprinidae** *Barbus holubi*	South Africa	Stocking Lakes	Successful and established in Lake
21	*Carassius auratus*	Madagascar, Mauritius.	-	
22	*Carassius auratus auratus*	South Africa		
23	*Carassius carassius*	Ethiopia		
24	*Catla catla*	Mauritius	-	
25	*Ctenopharyngodon idella*	Egypt, Kenya, Uganda, Sudan, Ethiopia & South Africa	Weed control in canals and dams Experimental Weed control in	Development was poor

26	*Cyprinus carpio* *Cyprinus carpio carpio* (common carp)	Cameroon, Central Africa Republic, Egypt, Ethiopia, Ghana, Kenya, Lesotho, Madagascar, Malawi, Morocco, Mozambique, Nigeria, Rwanda, South Africa, Swaziland, Togo, Tunisia, Uganda, and	Aquaculture, Experimental culture in fish farm, lakes, rice fields, dams, pond culture rural fish culture	Successful; In some cases, first stock disappeared from ponds
27	*Hypophthalmichthys molitrix*	Egypt, Ethiopia	Experimental;	Development was poor
28	*Labeo rohita*	Mauritius	and for stocking dam & rice fields	
29	*Scardinius erythropthalmus*	Tunisia, Morocco Madagascar		
30	*Tinca tinca*	Tunisia & Madagascar	For rural development for stocking rice fields	
31	**Percidae** *Perca fluviatilis*	Morocco	-	
32	*Lucioperca lucioperca*	Morocco	-	
33	*Gambusia affinis*	Worldwide distribution, Central African Republic, Sudan, Ghana, Madagascar, Ivory Coast & Egypt	Control of mosquito larvae and malaria in lakes, rivers	Disappeared from ponds after few months
34	**Anabantidae** *Osphronemus goramy*	Uganda, Madagascar & Mauritius		
35	*Osphronemus olfax*		-	
36	**Osteoglossidae** *Heterotis niloticus*	Benin, Cameroon, Central African Republic, Congo Democratic Republic, Gabon, Gambia, Ivory Coast, Togo, and Madagascar	For experimental culture in fish ponds	Successful and flourishing
37	**Clariidae** *Clarias lazera* *Clarias gariepinus*	Cameroon, Gabon	For pond culture and control of *Tilapia*	Successful
38	**Centropomidae** *Lates niloticus*	Uganda	To fill niches in Lake Kioga	
39	**Cichlidae** *Astatoreochromis alluaudi*	Central African Republic	For snail control	
40	*Etropolus sp.*	Mauritius	Hybridization (with *T. zillii*)	Abandoned in fish culture (in some cases)
41	*Tilapia andersonii*	Tanzania		
42	*T. aurea*	Uganda		
43	*T. hornorum*	Uganda & Ivory Coast		
44	*T. macrochir*	Central African Rep., Madagascar, Ivory Coast, Ghana & Mauritius		
45	*T. melanopleura*	Sudan, Madagascar, Uganda, Mauritius	For weed control in rivers	Eliminated
46	*T. mossambica*	Egypt, Madagascar, Tunisia, Uganda	For hybridization and pond culture	Abandoned
47	*T. nigra*	Madagascar, Uganda	For stocking natural water bodies (like Lake Naivasha, Kenya)	Abandoned in fish culture
48	*T. nilotica*	Central African Republic, Tunisia, Ivory Coast, Mauritius		
49	*T. rendalli*	Central African Republic, Madagascar, Ivory Coast Ethiopia, Kenya	For hybridization and pond culture	
50	*T. shirana*			
51	*T. zillii*			

52	*Tilapia mariae*	U.S.A	Aquarium	Escaped into the wild and attained dominance, destabilizing aquatic communities
53	*Serranochromis robustus*	South Africa	-	
	Poecilidae			
54	*Xiphophorus maculatus*	Nigeria	Aquarium fish	Successful
55	*Poecilia reticulata*	Nigeria	Aquarium fish	Successful
56	**Clupeidae** *Limnothrissa miodon*	Zambia, Rwanda	Fill vacant niches as Pelagic species in Lake Kariba (Zambia), L. Kivu (Rwanda)	Development was poor
57	**Ictaluridae** *Ictalurus punctatus* (channel catfish)	Nigeria	Aquaculture in fish farms	Not successful
58	**Astacidae** *Pacifastacus leniusculus* (Signal crayfish)	U.K	Aquaculture in fish farms and gourmet item	Escaped into the wild & introduced new diseases lethal to native species
59	*Procambarus clarkii*	Uganda, Malawi Gambia, Mauritius, Seychelles	For experimental culture in fish ponds	Development was poor
60	**Palaemonidae** *Macrobrachium rosenbergii*			
61	**Ostreidae** *Crassostrea gigas*			
62	*C. virginica*	Mauritius		
63	*O. edulis*	Mauritius		

***Source**: This study [modified from FAO (1976), Boden et al. (2004) and literature]*

States of America as the main shrimp importer, followed by Japan. Black tiger shrimp (*Penaeus mondon*), Chinese shrimp (*Fenneropenaeus chinensis*), and Pacific white shrimp (*Litopenaeus vannamei*) are the major marine crustacean species commercially cultured. The next is **salmon** (*S. salar*) and **trouts** (*O. mykiss*) which increased considerably to more than 14%. Norway remains the dominant producer and exporter of Atlantic salmon, closely followed by Chile. Wild Pacific salmon also plays an important part in world salmon markets representing 30% of the total market for salmonids. **Groundfish** species (about 10%). Brazil has become a growing destination for Norwegian cod, following the economic crisis faced by the major importers, particularly Portugal. The next major economic species are **Tuna** (8%), cephalopods like squid, cuttlefish and octopus (4%) and ***Pangasius,*** a freshwater low-priced fish from Viet Nam, and relatively recent arrival in international fish trade (FAO, 2012).

Introduction of Alien Species to Augment Species Diversity

Fish species introduced into areas from which they were previously absent are termed *exotic* or *alien* species. An introduced species may be native or indigenous, exotic or alien; but *introduced* does not equal *invasive*. Introduction of non-indigenous or exotic species into new areas is a common practice in fisheries management. Some fish species naturally travel across national borders in the course of their livelihood, thereby enriching the fisheries in new areas different from their original habitat. However, fish escapes from fish farms and aquaria, deliberate introductions, and the release of exotic organisms via a ship's ballast water and hull fouling have profound implications for fisheries resources and aquaculture. Howard (2004) distinguishes these species types as (i) ***native species*** - a species, subspecies or lower taxa occurring within its natural range and dispersal potential (i.e., within the range it occupies naturally or could occupy without direct or indirect introduction or care by

humans). (ii) ***alien species*** or alien genotype (introduced, non-indigenous, exotic) - a species, subspecies or lower taxon occurring as a result of human agency in an area or ecosystem in which it is not native. A domesticated or genetically altered native species may become an alien genotype. (iii) ***invasive species*** - a species which colonizes natural or semi-natural ecosystems. It is an agent of change and threatens native biodiversity (species, populations and/or ecosystems). (iv) ***alien invasive species*** combined (ii) and (iii) above often has the most serious or severe effects because it has not evolved in harmony with the ecosystem, for example it may have no natural "enemies".

Pre-existing aquaculture species imported or transferred from other regions includes the Japanese Oyster, *Crassostrea gigas*, the Atlantic Salmon, *Salmo salar*, and the California abalone, *Haliotis rufescens*. Aquaculture is the main cause of non-indigenous species introduction, accounting for 38.7% of introduced species recorded in the Database on Introductions of Aquatic Species (DIAS) of the FAO (Garibaldi and Bartley, 1998; http://www.fao.org/fi/statist/fisoft/dias/index.htm).

The introduction of exotic species is a management technique that has witnessed a wide use, particularly for the development of aquaculture. Copping and Smith (2005) outlined several principles and reasons for introduction of exotic species to include:

i. For aquaculture purposes for culture in pond culture, rice fields and rural fish culture; some exotic fish grow better than local species.
ii. For biological control of disease organisms and unwanted species, e.g., weed, snail, malaria control.
iii. To supplement or replace fish recruitment by natural reproduction.
iv. For stocking natural waters for optimal utilization of small and seasonal water bodies.
v. To create stocks of desirable species of exceptional value as in sport/recreational fisheries enhancement, live bait or ornamental fisheries and aquarium trade.
vi. To fill vacant ecological niches in new (man-made) or existing lakes.
vii. For the purpose of research by scientific research institutions, schools and public aquariums.
viii. For hybridization, i.e., when offspring of a cross between local and exotic fish species do better than their parents.
ix. To rapidly and cost-effectively develop and diversify aquaculture interests.
x. To minimize costs of research and development through use of overseas research and development outputs.
xi. To utilize pre-existing markets (such as restaurants, seafood retail and processing) with well-established brand identity to create a more rapid profit.

Impact of Introduced Exotic Species

Impact of Introduced Species on Native Fish Community and Aquatic Biodiversity

James (2009) reckoned that exotic species have positive and negative environmental impacts (Table 2). Introduced exotic species tend to escape into the local streams, and eventually spreads over a wide area and unless the species cannot withstand competition with the local fish fauna and is soon eliminated. Once introduced, the exercise cannot be undone or repaired as with a chemical accident. It is a permanent thing and its impact on the local fish goes on throughout time.

Table 2: Positive and negative environmental impacts of introduced exotic species on biodiversity

Positive impacts	**ative impacts** (in order of decreasing importance/threats to biodiver
• Cultured seafood can reduce pressure on overexploited wild stocks, • Stocked organisms may enhance declining and depleted natural stocks, • Aquaculture often boosts natural production and species diversity, and • Employment in aquaculture may replace more destructive	• Escapement of aquatic crops and their potential hazard as invasive species. • The relationships among effluents, eutrophication of water bodies, and changes in the fauna of receiving waters. • Conversion of sensitive land areas such as mangroves and wetlands, as well as water use. • Other resource use, such as fish meal and its concomitant overexploitation of fish stocks. • Disease or parasite transfer from captive to wild stocks. • Genetic alteration of existing stocks from escaped hatchery

A brief review of the potential environmental impacts associated with the introduction of exotic species into aquatic ecosystems includes the following:

Socioeconomic distortions

Investment in the transfer, domestication and farming of exotic species are enormous (Delgado *et al.,* 2003). For example, the introduction of zebra mussel into the U.S. resulted in a $3 billion loss to the economy and fishery or about $137 billion total loss annually (Goldsborough, 2003). A halt to importation and trade in exotic species for aquaculture purpose will not only reduce total aquaculture production but also affect the stability of seafood supplies and prices. Hence, adoption of precautionary measures is best.

Habitat alterations and Range expansion

Exotic species possess a high potential to become invasive species through aggressively exploring new habitats and niches and a broad environmental tolerance, thereby spreading far from the regions and areas where they were originally introduced. This makes them capable of destroying habitat through elimination of nursery areas for native juvenile fishes, accelerating eutrophication, and causing bank erosion (Kohler and Courtenay, 1986). They also impair water quality, causing anoxic conditions when they die and decompose, and alter predator-prey relationships (Deegan and Buchsbaum, 2005).

Trophic alterations and competition with native species

Introduced species can alter the trophic structure of an ecosystem via increased competition for food and space between native and non-native species (Kohler and Courtenay, 1986; Caraco *et al.*, 1997; Strayer *et al.*, 2004; Deegan and Buchsbaum, 2005) as well as through predation by introduced species on native species (Kohler and Courtenay, 1986). Competition could result in predation on (or increased mortality of) native species which in turn may result in decline in recruitment and displacement of native species from their natural habitat. Hence, competition contributes to decline in population size and hence, a shift in trophic structure of aquatic communities (Kohler and Courtenay 1986). For example, introductions of the invasive zebra mussel (*Dreissena polymorpha*) in the Hudson River estuary in New Jersey in the USA is associated with a decline in abundance (eggs, juveniles, or adults) of native forage species which affects the entire food web; decreased growth rate, and a shift in the population distribution of commercially and recreationally

important species (Strayer *et al.*, 2004). Other examples include:

a. Introduced *Tilapia mariae* was observed to have killed native species competing with it.
b. Zebra mussels have altered trophic structure in the Hudson River estuary by withdrawing large quantities of phytoplankton and zooplankton from the water column, thus competing with planktivorous fish. Phytoplankton is the basis of the food web, and altering the trophic levels at the bottom of the food web could have a detrimental, cascading effect on the aquatic ecosystem.
c. Increased competition for food between the zebra mussel and open-water commercial and recreational species such as the American shad (*Alosa sapidissima*) and black sea bass (*Centropristis striata*) has been associated with large, pervasive alterations in young-of-the-year fish, which could result in interspecies competition and alterations in trophic structure (Strayer *et al.*, 2004; Deegan and Buchsbaum, 2005).
d. The Asian shore crab invaded Long Island Sound and exhibits an aggressive predatory behaviour and voracious appetite for crustaceans, mussels, young clams, barnacles, periwinkles, polychaetes, macroalgae, and salt marsh grasses. The removal of the forage base by this invasive crab could have a ripple effect throughout the food web that could restructure communities along the Atlantic coast (Tyrrell and Harris, 2000; Brousseau and Baglivo, 2005).

Alterations to communities

Introductions of non-native species may result in alterations to communities and an increase in competition for food and habitat. For example, the green crab is an exotic species from Europe which preys on native soft-shelled clams and newly settled winter flounder (*Pseudopleuronectes americanus*) (Deegan and Buchsbaum, 2005). Non-native marsh grass introductions can alter habitat conditions, resulting in changes in the fauna of salt marsh habitat. Alterations to communities have been noted in areas in which native marsh cordgrass habitat has been invaded by the invasive, exotic *Phragmites* (Posey *et al.*, 2003). *Phragmites* has been implicated in alteration of the quality of intertidal habitats, including: lower abundance of nekton in *Phragmites* habitat; reduced utilization of this habitat by other species during certain life stages (Weinstein and Balletto, 1999; Able and Hagan, 2000); decreased density of gastropods, oligochaetes, and midges (Posey *et al.*, 2003); decreased bird abundance and species richness (Benoit and Askins, 1999); and avoidance of *Phragmites* by juvenile fishes (Weis and Weis, 2000). Introduced non-native species could also compete for spawning ground, e.g., *Tilapia mariae* was observed to have kept the Black Acara (*Cichlasoma bimaculatum*) off their normally occupied, shallow water spawning areas and restricting them to the edge of canal banks. Also, common carps are known to stir up muddy bottoms thereby disturbing other fishes.

Genetic erosion, pollution and alterations of wild stocks

All aquaculture species could escape from captivity into the natural waters or their eggs, larvae and fingerling could be transported to areas where they were hitherto absent, e.g., through ballast water of ships (Goldburg and Triplett, 1997; USCOP, 2004; BWM, 2005). Such exotic and non-endemic species still exhibit high genetic variability, short generation time, rapid growth, and early sexual maturation, common among aquaculture species. This creates opportunities for exotic species to hybridize or inter breeding with native species that are genetically less divergent thereby weakening the unique genetic identity and integrity of wild populations and decreasing their fitness via breakup of gene combinations (Goldburg *et al.*, 2001) and loss of fitness and depletion of native

genotype (Kohler and Courtenay, 1986; USFWS and NMFS, 1999).

Na-Nakorn *et al.* (2004) reported that introduced farmed *C. gariepinus* introduced genetic introgression in the native walking catfish, *Clarias macrocephalus,* in Thailand. His report was substantiated by Penman *et al.* (2002) and Senanan *et al.* (2004) in the farming of non-indigenous carps and hybrid catfish (*Clarias macrocephalus* × *C. gariepinus*), respectively.

In the Gulf of Maine, the wild Atlantic salmon (*Salmo salar*) population currently exhibits poor marine survival and low spawning stock and is in danger of becoming extinct, which makes the species particularly vulnerable to genetic modification via interbreeding with escaped aquaculture species. Any genetic modification combined with other threats such as reduced water levels, parasites and diseases, commercial and recreational fisheries, loss of habitat, poor water quality, and sedimentation may threaten or potentially extirpate the wild salmon stock in the Gulf of Maine (USFWS and NMFS, 1999).

Introduction and Spread of Diseases Lethal to Native Species

Aquaculture production is vulnerable to adverse impacts of disease and environmental conditions. Disease outbreaks in recent years have affected farmed Atlantic salmon in Chile, oysters in Europe, and marine shrimp farming in several countries in Asia, South America and Africa, resulting in partial or sometimes total loss of production. In 2010, aquaculture in China suffered production losses of 1.7 million tonnes caused by natural disasters, diseases and pollution. Disease outbreaks virtually wiped out marine shrimp farming production in Mozambique in 2011 (FAO, 2012).

Introduced exotic species have been implicated often as vectors in the transmission of diseases or parasites to wild fish stocks. Bacteria, viruses, and parasites may be introduced advertently or inadvertently and can reduce habitat quality (Hanson *et al.*, 2003). The introduction of pathogens can have lethal or sublethal effects on aquatic organisms and has the potential to impair the health and fitness level of wild fish populations or contribute to the decline of native populations (USFWS and NMFS, 1999). Examples include the MSX (multinucleated sphere unknown) oyster disease introduced through the Pacific oyster (*Crassostrea gigas*) which contributed to the decline of native oyster (*Crassostrea virginica*) populations in Delaware Bay, in New Jersey and Chesapeake Bay (Burreson *et al.*, 2000; Rickards and Ticco, 2002) and the Infectious Salmon Anemia (ISA) that spread from salmon farms in New Brunswick, Canada, to salmon farms in Maine (USFWS and NMFS, 1999) all in the USA. Other examples include the case of rainbow trout (*Salmo gairdneri*) and Signal crayfish which introduced furunculosis and crayfish plague, respectively, into European fisheries. Most native species were eliminated due to low resistance to these new diseases. Reynolds (1988) also recorded crayfish extinction in Central Ireland following the introduction of crayfish plague by alien species. Salmon escapees from fish farms in Norway spread Salmon gill fluke parasite (*Gyrodactylus*) into several rivers in the U.K. (Anonymous, 2007).

However, James (2009) counseled against hasty conclusions linking transmission of diseases or parasites from farmed animals to wild fish stocks, as this could result in controversial debates and heated arguments with well-respected scientists lining up on both sides of the debate. Such a debate arose over sea lice–salmon issue in which some notable scientists predicted (or criticized) the entire loss and extinction of wild species following introduction of exotic species (Brooks, 2005; Brooks and Jones, 2008 versus Krkosek and colleagues, 2006). Adherence to the precautionary principle becomes apparent, hence the impact of aquaculture on disease and

parasite transfer should be treated with caution. Other sources of introduced pathogens include industrial shipping, recreational boating, dredging activities, sediment disposal, municipal and agricultural runoff, wildlife faeces, septic systems, biotechnology labs, aquariums, and transfer of oyster spat and other species to new areas for aquaculture or restoration purposes (ASMFC, 1992; Boesch *et al.*, 1997).

Southeast Asian countries, especially Taiwan, Philippine, and Indonesia conduct inter-country transfers of milkfish (*Chanos chanos*) fingerlings every year to meet demand (Lee, 1995). Most of the transfers were carried out without any examination of stock health conditions or gone through quarantine procedure. Pathogens could be transferred to new locations if the transported stock carried any infectious disease.

Furthermore, intensification of stocking densities and deterioration of culture conditions provided favourable conditions for the outbreak of shrimp diseases. The danger in such transfers is that microorganisms, along with the fish, can be transported from one region to another. Undesired pathogens can be unintentionally introduced to a new location and create other issues. Although no major outbreaks of diseases were reported, additional measures to prevent any negative impacts should always be taken. After all, the intra- and inter-regional transfers of shrimp stocks were one of the causes for the collapse of shrimp farming industries in several countries in Asia and other regions (Lin, 1989). Shrimp diseases caused by viral infection are not easily treated under current technology and have caused significant economic losses that have affected industry survival in many countries (Lightner, 2003). Shrimp viral disease outbreaks have caused billions of dollars in lost revenue for the global shrimp industry. Because of the uncontrolled transfer of stock, a disease outbreak in one area could also cause unintended consequences in other parts of the world through trade.

The outbreaks of Taura Syndrome Virus (TSV), White Spot Syndrome Virus (WSSV), and Infectious Hypodermal and Hematopoietic Necrosis Virus (IHHNV) were found in one location but were identified later in other countries (Lightner, 2003). Nunan *et al.*, (1998) reported that frozen shrimp from an infected area could serve as a vector for exotic shrimp viruses during seafood trade.

Dominance of Exotic Species in Fish Populations and Changes in Species diversity

Exotic species often become better adapted to the environment than native species. Through rapid natural reproduction they can rapidly dominate a new area and can cause changes within species communities to such an extent that native species are forced out of the invaded area or undergo a decline in abundance, leading to changes in species diversity (Omori *et al.*, 1994).

For example, the invasion of zebra mussels in the Hudson River, USA, caused localized re-distribution of species and changes in phytoplankton levels and trophic structure that favoured species of the littoral zone over open-water species, i.e., the zebra mussel invasion resulted in a decline in abundance of open-water fishes (e.g., American shad) and an increase in abundance for littoral zone species (e.g., sunfishes) (Strayer *et al.*, 2004). Similarly, the introduction of black bass into Mexico ruined the highly prized pescado blanco fishery. Also, *Tilapia mariae* and other *Tilapia* spp. often dominate new fisheries by over 50% total fish biomass. Bäck (1995) reported the replacement of the native crayfish *Astacus astacus* by the introduced species *Pacifastacus leniusculus* in a Swedish lake. Shifts in the distribution and abundance of species caused by introduced species can affect the diversity of species in an area.

Benthic species diversity can be altered by the introduction of shellfish for aquaculture purposes (Kaiser *et al.*, 1998) and for habitat

restoration projects. Cultivation of shellfish such as hard clams often requires the placement of gravel or crushed shell on the substrate. Changes in benthic structure can result in a shift in the community at that site (e.g., from a polychaete to a bivalve and nemertean dominated benthic community) which may have the effect of reduced diversity (Simenstad and Fresh, 1995; Kaiser *et al.*, 1998). However, community diversity may be enhanced by the introduction of aquaculture species and/or the modification of the substrate (Simenstad and Fresh, 1995). In addition, changes in species diversity may occur as a result of oyster habitat restoration. Oyster reefs provide habitat for a variety of resident and transient species (Coen *et al.*, 1999), so restoration activities that introduce oysters into an area may result in localized changes in species diversity, as reef-building organisms and fish are attracted to the restoration site.

Alterations in the health of native species

The health of native species can be impaired by the introduction of new species into an area. A number of factors may contribute to reduced health of native populations, such as competition for food may result in a decrease in the growth rate and local abundance (Strayer *et al.*, 2004) or the decline in the entire population (USFWS and NMFS, 1999) of native species; aggressive and fast growing non-native predators can reduce the populations of native species (Pederson *et al.*, 2005); diseases represent a significant threat to the integrity and health of native aquatic communities and can decrease the sustainability of the native population (Kohler and Courtenay, 1986; USFWS and NMFS ,1999; Rickards and Ticco, 2002; Hanson *et al.*, 2003); and the genetic integrity of native species may be compromised through hybridization with introduced species (Kohler and Courtenay, 1986), which can also decrease the fitness of wild species via breakup of gene combinations (Goldburg *et al.*, 2001).

The factors listed above, in combination with potential impact on the habitats of native species, can collectively result in long-term impacts to the health of native species (Burdick *et al.*, 2001; Minchinton and Bertness, 2003; Deegan and Buchsbaum, 2005; Pederson *et al.*, 2005).

Impacts to water quality

Invasive species can affect water quality in marine, estuarine, and riverine environments because they have the potential to outcompete native species and dominate habitats. For example, non-native aquatic plant species, which may not have natural predators in their new environments, can proliferate within water bodies, impair water quality, and cause anoxic conditions when they die and decompose. Fish species such as grass carp (*Ctenopharyngodon idella*) and tilapia (Cichlidae), introduced to control noxious weeds, can accelerate eutrophication through faecal decomposition of nutrients previously stored in the plants (Kohler and Courtenay, 1986). In addition, fish introduced to control invasive plant species can increase turbidity in the water column from their grazing behavior (Kohler and Courtenay, 1986).

Managing Biodiversity in Aquaculture

In comparison, the number of species grown and systems used in aquaculture production is significantly more diverse than in agriculture and livestock farming. But the contribution of each species to overall production (also called evenness) is highly skewed; 30 aquatic species provide about 90 percent of aquaculture production. This is nothing compared to the close to two thousand species that contribute to capture fisheries. Species evenness could be attained through increased production of the currently less productive species/strains (Harvey *et al.,* 2017).

The diversity of fishes used in aquaculture arise from the different types of aquaculture production practices, the different degrees of culture intensity and technological and

managerial sophistication and the diversity of fishes inhabiting natural water bodies including freshwater, brackish-water, marine water, inland saline water and wetlands. While more than 1,800 species are fished; 622 species are produced in aquaculture: 466 individual species, 7 interspecific hybrids of finfish, 92 species groups at genus level, 32 species groups at family level, and 25 species groups at the level of order or higher. This number increased by 31.8%, from 472 in 2006 to 622 in 2018, (i.e., over 200-300 new species added in FAO database following improvement in data collection). Finfish farming, the most diverse subsector, contains 27 species and species groups, accounting for over 90 percent of total finfish production in 2018 (FAO, 2020). An examination of DIAS (http://www.fao.org/fi/statist/fisoft/dias/index.htm) revealed that 139 species from 87 genera have been introduced into 42 African countries. They include over 37 fin-fishes (79%); 5 shell-fishes or molluscs (7%); crustaceans (9%), and 17 non-endemic fish of which 10 are tilapias. Tilapia is the most important fish species that Africa has contributed to world fisheries and aquaculture. FAO Fishery statistics reveal that tilapias are farmed in 61 countries outside of Africa (33 in Africa) and these alien tilapia account for 2 per cent of the world aquaculture production. In Africa, tilapia accounts for about 40% of the aquaculture production.

Introduced species have increased aquaculture production (contributing about 17% of total global fish production in 1996), on the one hand; they also pose higher risks of spreading and becoming ubiquitous and difficult to eradicate, hence, a source of threat to aquatic biodiversity protection, habitat alteration, competition with native species for food and space, and trans-boundary transfer of disease; especially when introduced into farming practices that rarely provide a zero-risk of accidental release (Beveridge *et al.,* 1994; Bartley and Casal, 1998). De Silva *et al.* (2009) and Frimpong (2017) also assert food security, biodiversity, ecosystem services and biosecurity are tightly intertwined as enshrined in the millennium development goals); because local biodiversity and ecosystems are dynamic. In essence, in achieving food security, the exploitation of indigenous species and introduction of exotic species must be controlled to protect local species and habitats against the negative impacts of invasive species (Frimpong, 2017).

The FAO Code of Conduct for Responsible Fisheries reinforces the understanding and expectations of States to achieve SDG 14 targets/ indicators, particularly, managing biodiversity appropriately to ensure that the livelihoods of local communities, fishers and fishworkers; and their access to fishing grounds, are protected and not negatively affected by aquaculture developments.

Aquaculture Genetic Resources (AqGR)

The aquatic germplasm resources have enormous potential. Some of the species that contribute to aquaculture productivity globally are indigenous and endemic, genetically modified or improved strains while still a large number are exotic or alien species. Globally, production from wild-caught or capture fisheries is on the decline while aquaculture productivity is on the increase, contributing over 42 per cent of aquatic animal food for human consumption.

Typically, for most aquaculture species, diversity of aquaculture genetic resources (AqGR) is limited only at the species level. To correct this paucity of knowledge on farmed species, the FAO has designed schemes to enhance understanding and to develop knowledge products on AqGR. Such schemes include the standard reference list of species, Aquatic Sciences and Fisheries Information System (ASFIS). Each species item is assigned codes for more detailed classification according to their taxonomic, ecological and economic characteristics, under the FAO International Standard Statistical Classification for Aquatic

Animals and Plants (ISSCAAP). The AqGR information system and ASFIS therefore provide the framework or backbone for mapping and inventory of farmed species (Fig. 2). Researchers and scientists accredited and registered in the Aquatic Science and Fisheries Abstracts (ASFA) can contribute their research input for their coastal and inland waters to the AqGR database. Each farmed species must be identified as strain, variety, captive propagated, wild-sourced, hybrids, introgressed, cross-bred, polyploid, monosex (genetic), transgenic, gene edited or stocks (wild relatives).

Incidentally aquatic biodiversity of most natural ecosystems, especially inland waters, are being lost at alarming rates owing to overfishing, pollution, human-perturbations, among others. Within the aquaculture industry, new strains or species are being developed; often, farmers find it difficult to obtain or maintain pure breeds, while breeders have an uphill task to locate and collect genetic materials from healthy or relatively undisturbed wild populations. It is expected that the FAO AqGR database will provide credible information needed for the proper management of aquaculture species and strains.

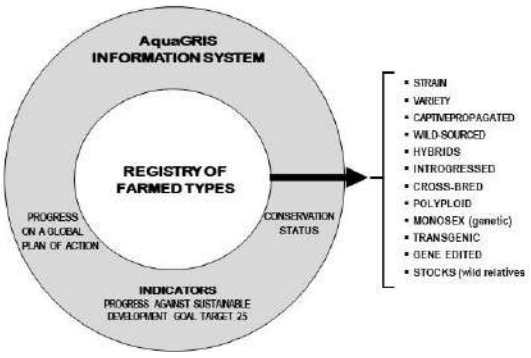

Fig. 2: Proposed information system with a registry of farmed types of aquatic genetic resources at its core (FAO 2020)

Upgrading the Quality of Cultivated Fishes and Fish Seed

African aquaculture has not benefited greatly either from the domestication of African species or the introduction of improved breed from elsewhere. Indigenous African species, ecotypes and wild species that are highly adapted to local ecotones, ecological niches, and low-input systems are considered important in risk-mitigation for local production. Their low-status image, lacking of efficient seed supply systems; and poor market structure need be developed; building on the rich traditional indigenous knowledge and self-esteem. To achieve this, deliberate efforts must be made to develop and employ modern genetic and biotechnological tools such as genetic characterization, selective breeding, transgenic genome transfer, hybridization studies; application of cryopreservation and tissue culture, chromosome-set manipulations, among others, in upgrading the quality of cultivated fishes and fish seed; and for conservation and management of genetic diversity in natural fish stocks. Such instance, include genetically improvement farmed tilapia (GIFT), and African catfish *Clarias gariepinus* (Ambali and Malekano, 2004). The production of 100% males of *Tilapia* spp. through hybridization with non-endemics should be popularized. Introduction and cultivation of shellfishes in Africa should be encouraged, while unsuccessful introductions should be eradicated (FAO, 1976).

The nation of Israel thrives in aquaculture mostly from introduced species such as koi carp (ornamental fisheries) and trout. The Israelis develop genetic modified aquaculture products targeting export to specific clienteles in Europe and Asia where the introduced species are native. They have created a niche for themselves. The Asians have popularized the low-priced Vietnamese *Pangasius* fish.

Africa is yet to develop any reckoning in its effort to develop aquaculture despite receiving exotic species. It behoves Africa to look inwards to

develop its indigenous species: through incentivized research and development attention; strategic sampling, understanding and characterization, rich knowledge of their ecology with possibilities for gene banking, conservation and utilization. Adeleke *et al.* (2021) reviewed critical success factors of aquaculture development in Africa and identified the strengths to include: high production outputs (tons) and value ($), culture of diverse aquaculture species, efficient aquaculture production technology/systems, well established Catfish value chain and commercial scale freshwater and mariculture and aquafeed manufacturing capacity. The strength of aquaculture development presents opportunities which include high per capita consumption of fish, burgeoning local demand, strong institutional support from government, growing processing and export potentials/markets. The aquaculture development challenges in Africa were related to fish seed, fish feed, land and water availability; poor governance and obsolete policies and frameworks, climate change and environmental issues, developing aquaculture market and trade links, overstretched and limited water resources, high focus on a single species like *Clarias gariepinus.* These challenges are surmountable because Africa is resource-rich but acting poor.

Africa is one of the most blessed continents in the world with a wide diversity of ecosystems: marine and terrestrial natural resources, freshwater, brackish-water, inland saline water, lakes, reservoirs, ponds and wetlands (DFID, 2002) suitable for aquaculture production and blue economy. Thirty-eight of Africa's 54 states are coastal, and maritime zones with additional 240,000 sq km lake zones with approximately 1,341,500 sq km of wetlands (Li *et al*., 2022) and transboundary river basins covering over 64% of the continent's land area. In recognition of these enormous potentials, Kitenge (2021) advocated diversification and robust implementation of Africa's Blue Economy Strategy in alignment with Agenda 2063.

Minimising the adverse impacts of aquaculture on wild stocks

One of problems facing aquaculture development in Africa is haphazard introduction of exotic species, sometimes illegally. The risks imposed by introduced species are categorized into four hazard levels as: *I*: The escape of an alien species with no close relatives with which to hybridize may impose drastic effect on aquatic communities by reducing the abundance of another species, even to the point of extirpation. *II:* The escape of aliens that have close relatives with which they can hybridize may impose the same consequences as in Hazard I level, with the addition of direct genetic consequences through interbreeding. *III:* The escape of aquaculture strain of native species into environments harboring populations of the same species may alter the genetic diversity and fitness of the wild population. *IV:* Finally, the escape of genetically engineered organisms, which may fit into any of the hazards above, introduces additional concerns that merit attention.

Bartley and Minchin (1996) and UNEP-MAP RAC/SPA (2015) outline the precautionary principles to be observed for risk-reduction, minimising adverse impacts, of such introductions on wild stocks:

- *Closed culture*: better containment to prevent escape of the organism; species not to compete with valuable native species to the extent of contributing to their decline).
- *Desk Research, Literature Review & Biological Risk Assessment:* A scientifically valid biological risk assessment should be conducted based on a thorough literature review; details include evaluation of the risk of genetic, ecological, and disease impacts in the proposed receiving environment, as well as the potential for introducing non-target species should be done; assessment of each potential hazard as to the probability of the

establishment and consequences of the establishment in the receiving environment and mitigation factors and management issues must be resolved before such introductions

- *Sterilisation*: easily induced way of avoiding direct genetic effects (not undergo cross breeding with native species and produce undesirable hybrids; be devoid of pests, parasites or disease agents and non- target species which might attack the native species).
- *Localisation*: locating farms away from wild populations, and choosing locations for sea ranching that minimise straying so as to reduce gene flow to wild populations; species to live and reproduce in equilibrium with the new environment.
- *Coastal parks*: providing totally protected areas for valuable wild populations; excludes exotic species within its range/area
- *Reduced or selective fishing:* protecting native populations by reducing fishing pressure or by directing that pressure toward cultured fish.
- *Restrictions on transport*: reducing the spread of exotic genes and diseases by restricting transport of live fish and eggs.
- *Gene banks:* counteracting extinction of local populations by the establishment of gene banks.
- *Minimal genetic differences from native populations:* reducing effects of gene flow by minimising the genetic differences between escaping or released fish and recipient wild populations
- *Training of workers:* basic training of aqua-culture workers (including non-specialists) to minimise the risk of accidental releases of organisms into aquatic ecosystems.
- *Precautionary principle:* The precautionary principle should be taken into account in the final outcome of the risk assessment in absence of scientific knowledge.

Harvey *et al.* (2017) further suggests that new candidate species should: have reliable seed supply and survival to harvest; be euryhaline and/or eurythermal; tolerate low oxygen and pollution; come from lower trophic levels; have cost-effective feed conversion; have short production cycles; comply with biosafety requirements; and be culturally acceptable and reflect evolving consumer preferences. The European Union exempts establishments practicing "closed" systems (i.e. 100% biosecure) from biodiversity regulations. However, cost implications are limiting (FAO, 2005-2012).

Obvious of these threats, South Africa, one of Africa's leading aquaculture nation applied the above risk assessment technique when introducing *Tilapia niloticus* to a new ecoregion within the country (Copp *et al.,* 2008).

Obligations of state parties in managing species in use in the aquaculture industry

Responsibilities for promoting sustainable aquaculture development is to be shared among government authorities, aquafarmers, manufacturers and suppliers of aquaculture inputs, processors and traders of aquaculture products, financing institutions, researchers, special interest groups, professional associations, non-governmental organizations, and others. A number of international, regional and national agreements, treaties and 'soft regulations' exist to manage alien species use in aquaculture systems. Such instruments are generally binding or obligatory and established to regulate the intentional use and transfer of alien/exotic species. These include United Nations Convention on the Law of the Sea (UNCLOS, 1982) and Convention on Biological Diversity (CBD, 1992). Other relevant laws include the Code of Practice on the Introduction and Transfers of Marine Organisms of the International Council for the Exploration of the Sea (ICES, 1984, 1988, 1995, 2005) and the Code of

Conduct on Responsible Fisheries of the Food and Agriculture (FAO, 1995).

These laws apply to alien/exotic species in aquaculture as follows:

a. The United Nations Convention on the Law of the Sea (UNCLOS, 1982) explicitly states that Parties should take measures "to prevent, reduce and control pollution of the marine environment resulting from the intentional or accidental introduction of species alien or new, to a particular part of the marine environment, which may cause significant and harmful changes thereto" (Article 196).
b. The Convention on Biological Diversity (CBD, 1992) provides three articles applicable to the management of Alien Species:
   - Article 3: (States must) ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction;
   - Article 8(h): (States must) prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species; and,
   - Article 14.1: (States must) ensure that the environmental consequences of its programmes and policies that are likely to have significant adverse impacts on biological diversity are duly taken into account.

Hewitt *et al.* (2006) lists some considerations governments, decision makers and managers should take into account when using - or deciding on the use of - alien species for aquaculture purposes to include: identifying the purpose for importation/introduction of alien species. Is it for aquaculture purposes, etc.; identifying the acceptable level of protection and the national regulations needed for importation of new species; national regulations and government agencies/Ministries responsible for management of these regulations; person responsible for the importation (e.g., private individual, resaerch agency/university, Industry or government are responsible for management of these regulations;identifying communication pathways, for appropriate monitoring systems.

Risk Assessment of Introduction of Alien Species for Aquaculture Purposes

In other to avert negative impacts of introduced species, it is essential to develop risk assessment tools, whether quantitative, semi-quantitative or qualitative to estimate or evaluate the impact of such introduced species based on its environmental, economic, social, cultural, biogeographical, historical and ecological characteristics. In addition, well-researched literature review of the history of introduced species, their establishment and invasion, data on the environment and the conditions of the source and recipient ecosystems, and, among others, should be conducted in the adoption of more environmentally friendly approaches.

Campbell (2005, 2006) provide one of such analysis (Tables 3, 4). Table 3 provides likelihood that the species will be released into an environment where it can survive (and hence could cause harm). Table 4 provides a suite of consequence matrices for species-based evaluations. Each consequence matrix should be completed in a transparent and participatory process, relying on an expert panel and explicit to the individual project proposal.

Table 3: Likelihood matrix (Event equals release of the species into an environment where it can survive)

Level	Descriptor	Description	Probability of event
1	Rare	Event will occur in exceptional	< 5%
2	Unlikely	Event could occur but not	5 - 25%
3	Possible	Event could occur	25 50%
4	Likely	Event will Probably occur in	55 - 75%
5	Almost	Event is expected to occur in	75 - 95%

Source: Campbell (2006)

Table 4: Risk Matrix. N = negligible; L = low, M = moderate; H = high; E = extreme

	Consequences				
Likelihood	**Insignificant**	**Minor**	**Moderate**	**Major**	**Significant**
Rare	N	L	L	M	M
Unlikely	N	L	M	H	H
Possible	N	L	H	H	E
Likely	N	M	H	E	E
Almost certain	N	M	E	E	E

Source: Campbell (2006)

For each value Copp *et al.,* (2008) introduced a risk scoring methodology (F-ISK toolkit, Table 5) to guide the introduction of Tilapia *Oreochromis niloticus* into South Africa (FAO, 2005-2012). The toolkit lists 49 questions that are to be answered for each species, providing a confidence level and justification (with source listed) for each answer. The questions and results of the assessment on *O. niloticus* can be found in Table 5. Their risk analysis on *O. niloticus* shows there is reasonable likelihood that:

i. There will be escapees from any established culture facility unless best management practises are followed;
ii. Unless barriers are provided, *O. niloticus* could potentially colonise and establish in previously un-invaded river catchments where it is introduced, but only in the warmer, tropical parts of the country where this species is able to reproduce successfully;
iii. In these areas, introduced tilapia will compete with and/or predate on indigenous species and as such may pose a risk to the continued survival of these native fish species especially those that are already rare or range restricted;
iv. There is a high likelihood that hybridisation will occur with indigenous species (especially other tilapia species); and
v. Diseases or parasites could be transferred to populations of indigenous fish species unless appropriate best management practises are adopted, and all individuals are certified disease free by suitably qualified veterinarians prior to introduction.

Consequently, an ecogeographical fish map (Swartz, 2012) was produced delineating areas recommended for the farming of alien invasive freshwater fish species like *O. niloticus* in South Africa. The maps were created using known distribution records, expert opinion and robust stakeholder participation (Table 5). First priority was to identify areas of conservation interest such restricted fish sanctuaries, free-flowing rivers (free from dam structures) and wetland areas in pristine and largely unmodified/natural condition, fish migratory routes, among others (Copp *et al.,* 2008; FAO, 2005-2012).

Six levels of protection were identified as areas for:

i. *No culture* – in restricted sanctuaries and wetland areas in pristine and largely unmodified/natural condition;
ii. *High biosecurity* – excluding restricted sanctuaries, in areas where the species is currently not present, but the climate is suitable, culture can be undertaken only in high biosecurity facilities such as in closed culture systems, i.e., Recirculating Aquaculture Systems, RAS.
iii. *Medium biosecurity* - where there is an existing population of *O. niloticus* (or *O. niloticus* hybrids) in open fishing areas, fish migratory routes or upstream areas, culture activities should be restricted to those with medium biosecurity measures in place (such as partial RAS). The construction of thermally-regulated intensive biosecure recirculation systems in tanks and raceways are the most suitable and least risky because they prevent the discharge of organisms and waste products into the surrounding environment.
iv. *Low biosecurity* – applicable to all other non-demarcated freshwater areas as well as in fish migratory routes, upstream areas and all remaining freshwater area, where *O. niloticus* is not found (and the climate is not suitable for the species to survive in the natural environment) dam, river or cage culture could be undertaken, in conjunction with single sex populations and/or triploid individuals. Cage culture of *O. niloticus* should be avoided in ecoregions which contain native populations of *O. mossambicus* (close relative), due to the risk of hybridization.
v. *Non-applicability*, i.e., in cases, where there is no native distribution of *O. niloticus* in South Africa.
vi. Some of the 'high biosecurity' categories were further categorised as number '1'. Aquafarms in such areas must employ high biosecurity measures in order to protect non-fish species which are threatened but not presently protected in South Africa's restricted fish sanctuaries or elsewhere. Fishing areas which do not contain *O. niloticus*, and the climate is deemed unsuitable, should be approached using the same strict guidelines conservation (Copp *et al.,* 2008; FAO, 2005-2012).

Conclusion

With proper attention, increased research focus and incentives, Africa and developing countries could achieve excellent production statuses and create wider markets through novel aquaculture products. This might take a long time, but is achievable just as the low-priced freshwater catfish, *Pangasius* species, from Viet Nam, made its way recently into the international fish trade. While protecting and propagating germplasms of indigenous species, precautionary approach should be adopted in the introduction of exotic species in aquaculture after appropriate risk assessment. Private sector aquapreneurs and aquafarmers as major stakeholders, should be encouraged in promoting aquaculture production using indigenous and/or exotic species. Aquafarms should operate in clusters or aquafarm estates to control potential environmental damage and peer-policing. aquaculture policies should incorporate growth and expansion aquaculture operations and balancing same with aquaculture sustainability and sufficient quality of catch and fishing-effort data for stock assessment and fisheries

sustainability. Research institutions should develop new aquaculture species, hybrid species and market for aqua-products for socio-economic sustainability of nations.

Table 5: Risk scoring methodology for *O. niloticus* and guidance supplied by the F-ISK toolkit

Q*	Risk query: Biogeography/historical	Reply	Comments & References	Certainty
1	**Is the species highly domesticated or cultivated for commercial, angling or ornamental purposes?** *Guidance*: This taxon must have been grown deliberately and subjected to substantial human selection for at least 20 generations, or is known to be easily reared in captivity (e.g. fish farms, aquaria or garden ponds).	Y	FAO (2012)	4
2	**Has the species become naturalized where introduced?** *Guidance*: The taxon must be known to have successfully established self-sustaining populations in at least one habitat other than its usual habitat (e.g. Lotic vs lentic) and persisted for at least 50 years (response modifies the effect of Q1).	Y	Picker & Griffiths (2011)	4
3	**Does the species have invasive races/varieties/sub-species?** *Guidance*: This question emphasizes the invasiveness of domesticated, in particular ornamental, species (modifies the effect of Q1).	Y	GISD (2012)	4
4	**Is species reproductive tolerance suited to climates in the risk assessment area (1-low, 2-intermediate, 3-high)?** *Guidance*: Climate matching is based on an approved system such as GARP or Climatch. If not available, then assign the maximum score (2).	1	Could be seasonally	3
5	**What is the quality of the climate match data (1-low; 2-intermediate; 3-high)?** *Guidance*: The quality is an estimate of how complete are the data used to generate the climate analysis. If not available, then the minimum score (0) should be assigned.	2	Kleynhans *et al.* (2005)	3
6	**Does the species have broad climate suitability (environmental versatility)?** *Guidance*: Output from climate matching can help answer this, combined with the known versatility of the taxon as regards climate region distribution. Otherwise the response should be based on natural occurrence in 3 or more distinct climate categories, as defined by Koppen or Walter (or based on knowledge of existing presence in areas of similar climate).	N	FAO (2012); Boyd (2004)	3
7	**Is the species native to, or naturalized in, regions with equable climates to the risk assessment area?** *Guidance*: Output from climate matching help answer this, but in absence of this, the known climate distribution (e.g. a tropical, semitropical, south temperate, north temperate) of the taxons native Range and the 'risk are' (,e, country/region/area for which the FISK is being run) can be Used as a surrogate means of estimating.	N	Picker & Griffiths (2011)	3
8	**Does the species have a history of introductions outside its natural range?** *Guidance*: Should be relatively well documented, with evidence of translocation and introduction.	Y	Fitzsimmons (2001)	4
9	**Has the species naturalized (established viable populations) beyond its native range?** *Guidance*: If the native range is not well defined (i.e. uncertainty about it exists), or the current distribution of the organism is poorly documented, then the answer is "Don't know".	Y	Picker & Griffiths (2011)	4
10	**In the species' naturalized range, are there impacts to wild stocks of angling or commercial species?** *Guidance:* Where possible, this should be assessed using documented evidence of real impacts (i.e. decline of native species, disease introduction or transmission), not just circumstantial or opinion-based judgments.	Y	Van der Waal (2000)	4
11	**In the species' naturalized range, are there impacts to aquacultural, aquarium or ornamental species?** *Guidance*: Aquaculture incurs a cost from control of the species or productivity losses. This carries more weight than Q10. If the types of	?	No record of this	2

	species is uncertain, then the yes response should be placed here for more major species, particularly if the distribution is widespread.			
12	**In the species' naturalized range, are there impacts to rivers, lakes or amenity values?** *Guidance*: documented evidence that the species has altered the structure or function of natural ecosystems.	Y	Starling *et al.* (2002)	4
13	**Does the species have invasive congeners?** *Guidance*: One or more species within the genus are known to be serious pests	Y	GISD (2012)	4
14	**Is the species poisonous, or poses other risks to human health?** *Guidance*: Applicable if the taxon's presence is known, for any reason, to cause discomfort or pain to animals.	N	No reference	4
15	**Does the species out-compete with native species?** *Guidance:* known to suppress the growth of native species, or displace from the microhabitat, of native species.	Y	Angienda *et al.* (2011)	4
16	**Is the species parasitic of other species?** *Guidance*: Needs at least some documentation of being a parasite of other species (e.g. scale or fin nipping such as known for top mouth gudgeon, blood-sucking such as some lampreys)	N	No reference	4
17	**Is the species unpalatable to, or lacking, natural predators?** *Guidance*: this should be considered with respect to where the taxon is likely to be present and with respect to the likely level of ambient natural or human predation, if any.	N	No reference	4
18	**Does species prey on a native species (e.g. previously subjected to low (or no) predation)?** *Guidance*: There should be some evidence that the taxon is likely to establish in a hydro system that is normally devoid of predatory fish (e.g., amphibian ponds) or in river catchments in which predatory fish have never been present.	N	No record of this	3
19	**Does the species host, and/or is it a vector, for recognized pests and pathogens, especially non-native?** *Guidance*: The main concerns are non-native pathogens and parasites, with the host being the original introduction vector of the disease or as a host of the disease brought in by another taxon.	Y	FAO (2012)	4
20	**Does the species achieve a large ultimate body size (i.e. > 10 cm FL) (more likely to be abandoned)?** *Guidance*: Although small-bodied fish may be abandoned, large-bodied fish are the major concern, as they soon outgrow their aquarium or garden pond.	Y	Bwanika *et al*. (2004)	4
21	**Does the species have a wide salinity tolerance or is euryhaline at some stage of its life cycle?** Guidance: Presence in low salinity water bodies (e.g. Baltic Sea) does not constitute euryhaline, so minimum salinity level should be about 15‰.	N	No record of this	3
22	**Is the species desiccation tolerant at some stage of its life cycle?** *Guidance*: Should be able to withstand being out of water for extended periods (e.g. minimum of one or more hours).	N	No reference	4
23	**Is the species tolerant of a range of water velocity conditions (e.g. versatile in habitat use)?** *Guidance*: Species that are known to persist in a wide variety of habitats, including areas of standing and flowing waters (over a wide range of Velocities: 0 to 0.7 m per sec).	Y	FAO (2005 - 2012)	3
24	**Does feeding or other behaviours of the species reduce habitat quality for native species?** *Guidance*: There should be evidence that the foraging results in an increase in suspended solids, reducing water clarity (e.g. as demonstrated for common carp).	Y	Angienda *et al.* (2011)	4

Source: Copp et al., (2008) Q* = Question

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Analysis Of The Pattern And Utilization Of Domestic Water Supply In Dukku Local Government Area, Gombe State, Nigeria

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Abstract: *This study analyzed domestic water supply and utilization in Dukku Local Government Area, Gombe State. Multi-stage sampling techniques were used to sample three hundred and seventy (370) respondents randomly selected from six (6) wards. The research centered on primary data acquired through questionnaire, focus group discussion. Data generated was analyzed using descriptive statistics (Tabulation, Percentage and Graphical presentations) and inferential analytical techniques (Analysis of Variance, (ANOVA). Results indicated that the total number of respondents who were not satisfied with the various sources of water was 78%. Most of the people in the six (6) selected wards travelled within the range of 13km in order to fetch water. Majority of the households sampled (90%) used the streams, rivers and boreholes. The study revealed that the amount of water obtained in liters from different sources and the quantity of water used for various domestic purposes vary significantly from one ward to the other. It is concluded that Dukku L.G.A per capita water consumption level is grossly inadequate as compared to the internationally accepted standards for rural areas. Hence, the study recommended among others the sinking of more boreholes in the community to boost water supply and ease accessibility.*

Keywords: domestic water, pattern, utilization, water supply

CITATION:
Kim, I., Dan, Y., Samaila, B. and Audu, H. O. (2023). Analysis of the Pattern and Utilization of Domestic Water Supply in Dukku Local Government Area, Gombe State, Nigeria. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 157-167

Introduction

Research documented that over 70% of the earth's surface is covered by water; hence, life itself generally depends on water (O'Sullivan, 2019). The origin and evolution of life became possible on earth because of the presence of water, animals, and plants (Chaitanya and Zenhausern, 2015). Water is a very essential resource to human life, which is only next to oxygen in terms of value to humankind. This is because it serves as life support and a source of hygiene, which is an essential ingredient of well-being (Mohammed, 2015). Furthermore, it functions as a production factor in our society, a source of energy generation, a transportation channel in riverine areas as well as source of recreational facility. It is a significant amenity and thus represents great aesthetic values (Emalia 2005).

The quest to make water available for domestic purposes is as old as human

existence on the globe. In keeping with World Health Organisation (WHO) (2015), about 663 million people globally lack access to adequate drinking water supplies, and approximately half of the people using unimproved water sources reside in sub-Saharan Africa (United Nations Children's Fund (UNICEF) and WHO, 2019). For example, in Nigeria the primitive method of producing water for domestic uses comprises direct collection of rainwater in containers, extraction of raw water from springs, streams, ponds and hand dug wells (Emalia, 2005; Ezenwaji, 2012). Water resources in Nigeria, are estimated at 226 billion cubic meters of surface water and about 40 billion cubic meters of ground water (Ayandiran *et al.,* 2018).

This indicates that Nigeria is blessed with abundant water resources but her rural populations are principally disadvantaged and deficient in terms of access to adequate water supplies (Adah and Abok, 2013). Nearly 65 million Nigerians have no access to safe and adequate water supplies; the number rose dramatically to 90 million in 2015 according to Unicef (2015). The inadequate access to water supplies by an important proportion of the Nigerian rural population has been blamed on institutional and socio-economic factors (Toyobo and Tanimowo, 2011; Adah and Abok, 2013; Ezenwaji *et al*., 2016).

Most studies on domestic water supply, demand, and use, such as studies by Abbas, 2010; Enefiok and Ekong, 2014; Kevin, 2015; Obeta, (2017) focused on urban areas. Little attention has been given to rural areas where majority of the population live. Therefore, the need to undertake studies on domestic water supply and utilization in rural settlements is needful. Consequently, the study focused on the patterns of domestic water supply and utilization in Dukku L.G.A, Gombe State.

Objectives of the Study

The study aimed at investigating the nature of domestic water supply and utilization in Dukku L.G.A. The specific objectives were to:

i. Describe the socioeconomic characteristics of the respondents
ii. Determine the wards and sources of water supply
iii. Assess the satisfaction level of people with the sources of water supply
iv. Ascertain decision taken by the respondents about water shortage
v. Assess the amount spent daily on water
vi. Determine the distance travelled to fetch water daily
vii. Examine the quantity of water supplied and used daily for conventional domestic purposes (in Litres)

Methodology

Study Area

Dukku Local government is located between latitude 10° 47' N and 10° 49' N and longitude 10° 41'E and 10^0 48'E. It is situated at about 78km from Gombe, the capital city of Gombe State. Dukku L.G.A is bounded by Bauchi state to the west and north-west, to the Northeast by Nafada L.G.A, Funakaye L.G.A to the east and Kwami L.G.A to the south as well as Akko L.G.A to the south-west. In terms of size, Dukku L.G.A occupies a total land area of about 3,815km^2, with a total population of 315,763 according to the National Population Census (NPC, 2006).

Sample size and Sampling Techniques

The study area is Dukku LGA, which is made up of eleven wards. Multi-stage sampling technique was adopted for the study. First, cluster sampling was used to divide Dukku LGA into three based on geographical zones of North, Central and South, respectively. Secondly, systematic sampling technique was used; where the various Wards were listed alphabetically and serially numbered. Thereafter, every first and

last ward was selected per zone based on the ease of access to give six Wards. The fourth stage involved the use of random sampling technique with a table of random numbers to determine the actual settlements from which respondents were drawn as shown in Table 1.

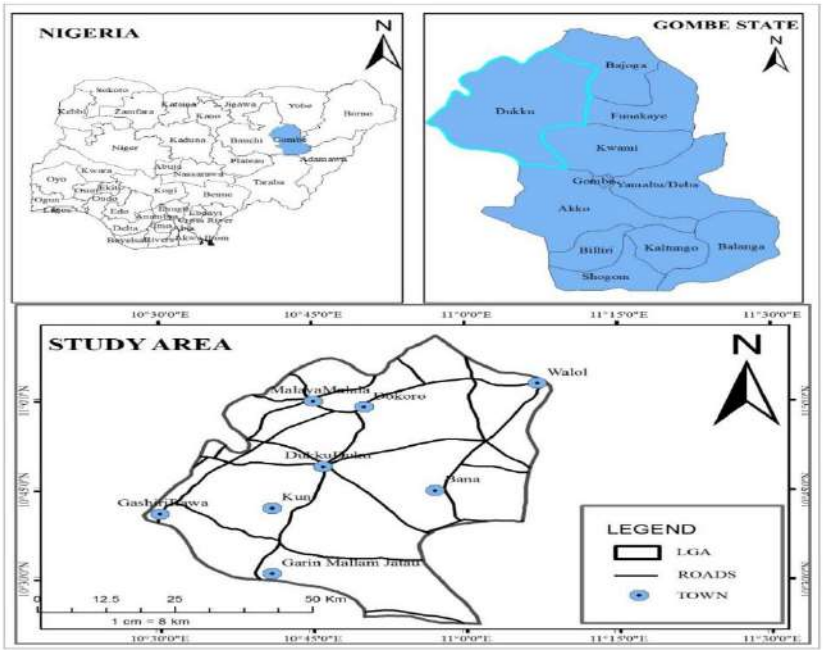

Fig.1: Map of the Study Area (Source: GIS and Remote sensing, Department of Geography, Gombe State University, Gombe)

Table 1: Selected settlement and distribution of sample size by communities

Geographic zone	Selected Wards	Selected Communities	Population (1991)	Projected population (2018)	Sample size
		Kaloma	2,066	4,902	63
	Jamari	Lafiya	778	1,846	24
		Burari	1,457	3,457	44
Dukku North	Malala	Gadum Mala	1,294	3,070	40
	Waziri	Bul-Bul	1,120	2,657	34
	North	Suka	1,079	2,560	33
Dukku	Waziri	Shawabe	547	1,298	17
Central	south	Nakuja	1,182	2,804	36
	Zange	Zagala	1,682	3,991	51
		Seyum	239	567	07
	Gombe	Waloji	754	1,789	23
Dukku South	Abba	Gaji Gala Jalingo	901	2,138	28
TOTAL	**6**	**12**	**13,099**	**31,079**	**400**

Source: Author's compilation, 2019.

The total population of selected communities in Dukku LGA is 31079 (NPC, 1991). To obtain the sample size, population of the communities was projected to 2018 using exponential formula $(P_{t+n} = P_{t^e}{}^{r*n})$..... (1)

Where,

P_{t+n} = Population at the future date (2018), P_t = Base year population (1991), e = exponential, r = Growth rate (3.2%), n = interval between the base year and the future year (2018-1991= 27). Using 3.2% inter-census growth rates for Gombe State (NPC, 2006). It will give a population size of 31079 (2018).

Yamane (1967) proposed a formula, expressed in Equation (2)

$SS = \frac{N}{1+N(e^2)}$ .....*(2)*

Where, SS= sample size, N= Population size, e = sampling error of 0.05 significant level) was used to calculate the sample size. The above formula was used to obtain 400 as sample size for the study.

To determine the proportion of respondents per unit area (community), Yamane (1967) was also used in Equation (3)

$\frac{n \times ss}{N}$ .....(3)

Where n= population of each community, ss= sample size, N= Total population of selected the communities.

In each of the communities, the total number of questionnaires as stated in Table 1 were systematically distributed to each household head starting with every 5th house. The head of household was purposively selected to supply all the information required and if not available, the eldest person was selected because they are likely to have the most knowledge about household characteristics, behaviours and needs.

Data Analysis

The data acquired for the study were analyzed using frequency tables, mean, scores and percentages.

Results and Discussion

Socio-Economic Characteristics of Respondents

Table 2 provides details on the respondents' socioeconomic characteristics. The study participants were predominately male, with 85% of them being male and 15% being female, according to the sex data. This may be because the heads of households were easier to reach when questionnaires were delivered, considering the study area's cultural background, which makes it difficult to reach married women.

Table 2: Socio-Economic Profile of the Respondents

S/N	Variable	Number	Percentage
1	**Sex**		
	Male	316	85
	Female	54	15
2	**Marital Status**		
	Married	234	63
	Single	51	14
	Divorce	45	12
	Widow	40	11
3	**Occupation**		
	Farmers	262	71
	Civil Servants	74	20
	Trading	34	9
4	**Education**		
	Primary	135	36
	Secondary	153	41
	Tertiary	42	12
	Others	40	11

Field work, 2019.

Additionally, according to Table 2, 63 percent of respondents are married, 14 percent are single, 11 percent are widowed, and 12 percent are divorced. Therefore, it may be concluded that more than half of the respondents were married, 1/7 were single, and just over 10% were widowed. The prevalence of marriage in the research area is not unrelated to the tradition of early marriage there, and the low number of

widows may be the result of Islam, the area's most prevalent religion, which supports polygamy.

Nearly three-quarters of the respondents to the survey who were asked about their occupations are farmers, followed by 20% of civil workers and 9% of business owners. As a result, Table 2's findings show that farmers outnumber both government employees and company owners combined in the Dukku Local Government Area. There might not be enough white-collar occupations, which would explain the large number of farmers.

The distribution of responders by educational background is again shown in Table 2. According to the table, respondents who attended higher institutions and received certificates there made up 13% of the respondents, while those with other credentials, such as informal education, made up 11%. 36 percent of respondents had a primary qualification, while 41 percent had a secondary qualification, making up the total number of respondents. As a result, in the study area, more people have graduated from high school than from other levels of education.

Wards and Sources of Water Supply

According to Fig. 2 result, Gombe Abba ward had the highest number of households that depend on streams or rivers for their sources of water supply, while Waziri North and Waziri South had the highest number of households that depend on boreholes and wells for their sources of water supply respectively. Figure 2 reveals further that about 50% of the households in the selected wards depend on wells as source of water supply, while 37% and 4% of them depend on or have boreholes and other sources of water supply respectively. The Table also indicates that only 6% of the households depend on rainfall as a source of water supply.

The results of the study suggest that most households in the selected wards rely on wells, boreholes, and streams or rivers for their sources of water supply. This could have significant implications for the health and wellbeing of these households, particularly if the water sources are contaminated or unreliable. For instance, households that rely on streams or rivers as their primary source of water may be at a higher risk of waterborne diseases such as cholera, typhoid, and diarrhoea due to the potential for contamination from human and animal waste, industrial pollution, and other sources. Similarly, households that rely on wells and boreholes may face challenges related to water quality, accessibility, and reliability, which can affect their ability to maintain good health and hygiene.

The results presented here are consistent with a study by Adjei *et al.,* (2018), which revealed that boreholes were the most often used source of water for residential uses, followed by streams and rivers. This study was conducted in a rural community in Ghana. The study also discovered that while most families had access to at least one water source, the quality of the water varied greatly depending on the source. In a similar vein, Abdullahi *et al.,* 2019 's study in Kaduna State, Nigeria, discovered that boreholes were the most prevalent source of water delivery for homes, followed by wells and rivers and streams. The survey also discovered that households in rural areas were more likely than those in urban areas to rely on rivers and streams for their water source.

The Satisfaction Level of People with the Sources of Water Supply

The assessed levels of satisfaction with regard to the various sources of water supply by residents of the six (6) chosen wards of Dukku L.G.A. are shown in Table 3. 78 percent of respondents overall express dissatisfaction with the sources, while 33 percent express dissatisfaction with the sources in one form or another. 41 percent of residents said they were dissatisfied with the availability of water from

streams and rivers, likely as a result of the daily travel distance.

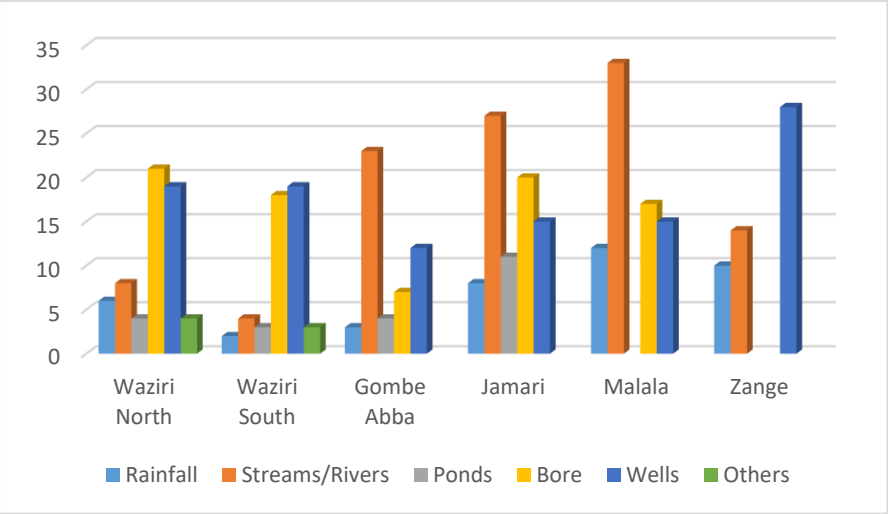

Fig. 2: Wards and Sources of Water Supply (Source: Field work, 2019)

Table 3: The Satisfaction Level of People with the Sources of Water Supply by Wards

S/N	Wards	Rainfall		Stream/ (River)		Ponds		Borehole		wells		Others	
		Ye	No	Yes	No	Ye	No	Yes	N	Yes	No	Yes	No
1.	Waziri North	-	6	-	8	2	3	10	1	2	17	1	2
2.	Waziri South	-	2	-	4	2	2	8	9	5	14	-	3
3.	Gombe Abba	-	-	7	19	-	4	-	6	4	9	-	-
4.	Jamari	-	-	13	22	-	9	17	9	-	11	-	-
5.	Malala	-	-	-	30	-	-	-	15	14	18	-	-
6,	Zange	-	11	-	12	-	-	-	-	-	29	-	-
	Total	**0**	**19**	**20**	**95**	**4**	**18**	**35**	**50**	**25**	**98**	**1**	**5**

Source: Field Survey(2019)

Table 3 also reveals that most of the people who are satisfied with their sources of water supply use borehole are (28) and (9) of them used wells as sources of water supply. Among the people 44% are (dissatisfied), with wells as source of water supply. This dissatisfaction may be attributed to the distance covered to fetch water as well as the depths of the wells The Table also implies that 78% of the wards have shortage of water supply since the quantity of water demanded is more than the quantity supplied per day in these wards. The study suggests that boreholes are the most preferred source of water supply among the respondents, followed by wells. However, there is a significant level of dissatisfaction among those who use wells, which can be attributed to the distance covered to fetch water and the depths of the wells.

Additionally, the study reveals that 78% of the wards are experiencing a shortage of water supply, which means that the quantity of water

demanded is more than what is supplied per day in these areas.

Table 4: Quantity of Water Demanded and Supplied Daily (in Litres) In the Households by Wards

S/No	Wards	Estimated Quantity of Water Demanded (Qd)	Estimated Quantity of Water Supplied (Qs)	Difference D = (Qs-Qd)
1.	Waziri North	15,156	14,150	- 1,006
2.	Waziri South	16,300	15,100	- 1,200
3.	Gombe Abba	12,225	10,102	- 2,123
4.	Jamari	14,425	18,250	+ 3,825
5.	Malala	13,750	9,220	- 4,530
6.	Zange	11,760	7,950	- 3,810
	Total	**83,616**	**74,772**	**-8,844**

Source: Fieldwork (2019)

Decision Taken by the Respondents about Water Shortage

Table 5 reveals that the respondents from the various wards made three decisions, one of which was the lack of water supply. The table shows that 489 people, or approximately half of the sampled population, believed they could survive on the daily amount of water provided to them. Trusting 8% of people to buy water when there was a shortage, whereas 34% changed the source of their water supply when there was a shortage.

The study suggests that a significant number of people in the sampled population believe they can survive on the daily amount of water provided to them, even though the amount may be insufficient. This indicates that people may be adapting to the water scarcity situation in the area, possibly by reducing their water usage or finding alternative sources.

The finding that 8% of people are willing to buy water when there is a shortage suggests that some individuals or households may have the financial means to purchase additional water, which may give them an advantage over those who cannot afford to do so.

The study also reveals that 34% of respondents changed their source of water supply when there was a shortage, indicating that people are willing to explore different options to meet their water needs. This may be an indication of resilience and adaptability among the population in the face of water scarcity.

Table 5: What People Do if the Quantity of Water was not sufficient

S/No	Wards	Decisions Taken About Water Shortage		
		Buy More	**Manage**	**Change the Source**
1.	Waziri North	16	31	15
2.	Waziri South	12	27	10
3.	Gombe Abba	10	27	12
4.	Jamari	24	37	20
5.	Malala	27	30	20
6.	Zange	14	26	12
	Total	**103(28%)**	**178(48%)**	**89(24%)**

Source: Fieldwork (2019)

Amount Spent Daily on Water

Table 10 shows the amounts spent by people on water in each ward on daily basis. According to the result, Waziri South spent about₦17, 950.00 daily on water that is about 27% of the total amount spent on water daily in the selected wards on water. This is followed by Waziri North, which spent about ₦13, 200.00 daily on water, and that made up about 20% of the total amount spent on water daily. The ward that spent the least amount of money on water is Zange ward with about ₦5, 230.00 (8%). Waziri South spent the highest amount of money on water, as much as ₦17, 950.00 (27.3%). Moreover, it can be deduced from the Table that the residents of the six (6) selected or sampled wards spent a lot of money on water for various domestic purposes i.e. a total of about ₦65, 780.00 is expended on water daily.

Quantity of Water Supplied and Used Daily for Conventional Domestic Purposes (in Litres)

Table 12 shows the quantities of water supplied and used daily for various conventional domestic activities in the wards. The domestic activities that are termed conventional activities or purposes include drinking, cooking, bathing, washing/laundry, sanitation/ablution, and others. The table, however, indicates that all the wards demanded and used 35,430 liters for drinking, 11,210 liters for sanitation/ablution, and 36,134 for cooking, 27,846 liters for bathing, 3,900 liters for washing/laundry and 7,580 liters for other things, all on daily basis. The quantities of water used for cooking were above the quantities supplied for the same purposes. However, in drinking, bathing and washing/laundry, the quantities of water supplied were much more than the quantities used daily by the households in the wards, while in sanitary/ablution and other things the quantities of water supplied were less than the quantities of water used. Most of the people in the wards were Muslims and used much quantities of water for sanitary and ablution purpose in addition to other use.

Table 10: Amount Spent Daily on Water Ward by Ward

S/no	Wards	Amount Spent (₦)	Percentage
1.	Waziri North	13,200,00	20.1
2.	Waziri South	17,950.00	27.3
3.	Gombe Abba	8,250.00	12.5
4.	Jamari	11,600.00	17.6
5.	Malala	9,550.00	14.5
6.	Zange	5,230.00	8.1
Total		**₦ 65,780,00**	**100.0**

Source: Fieldwork (2019)

Distance Travelled to Fetch Water Daily

Table 11 reveals that majority (48%) of the people in the six 6 sampled wards traveled within the range of 1-4km in order to fetch water. 35% moved a distance of 5-10km. Only few people (4%) travel beyond 14km in search of water. Jamari and Gombe Abba wards have most of their people traveling not beyond four (4) kilometers to fetch water; this may be due to location advantage to water sources. While those wards like Waziri north and Waziri south that have some people that are traveling about 15-20km are those that depend on water vendors (Tankers) to supply water to them. This finding is consistent with WHO/UNICEF (2014) who maintained that many households in the developing world, especially in rural areas in sub-Saharan Africa, lack piped water or access to nearby community water sources. It further stated that "Access to drinking water means that the source is less than 1 kilometer away from its place of use, while for the post-2015 SDG's, access to basic drinking water is proposed to be defined as "using an improved source with a total fetching time of 30 minutes or less for a round-trip including queuing (Benjamin 2016

Table 11: Distribution of Respondents by Distance Traveled to Fetch Water Daily Ward by Ward

S/No	Distance Traveled in Kilometers by Wards			
	l-4km	**5-l0km**	**ll-14km**	**15-20km**
1. Waziri North	16	20	15	11
2. Waziri South	13	20	11	5
3. Gombe Abba	37	12	-	-
4, Jamari	54	27	-	-
5. Malala	39	38	-	-
6. Zange	20	14	18	-
Total	**179**	**131**	**44**	**16**

Source: Fieldwork, 2019.

Table 12: Quantity of Water Supplied and Used for Conventional Domestic Purposes Daily (in Litres)

SN	Wards	Drinking		Cooking		Bathing		Washing/ Laundry		Sanitary/Ablution		Others	
		Qty. Sup	Qty. Used	Qty. Sup	Qty. Used	Qty. Sup	Qty. Used	Qty. Sup	Qty. Used	Qty. Sup	Qty. Used	Qty. Sup	Qty. Used
1.	Waziri North	6,044	4,750	7,000	4,634	2,236	1,836	5,600	5,000	3,900	2,400	3,520	2,260
2.	Waziri South	7,100	7,600	6,200	7,200	5,600	5,960	8,760	8,420	2,200	2,200	520	600
3.	Gombe Abba	4,200	4,300	4,600	4,900	3,650	3,840	6,220	6,500	900	1,000	634	830
4.	Malala	3,800	4,300	4,660	4,920	4,310	4,820	4,640	5,050	630	780	400	680
5.	Jamari	10,400	10,700	9,780	9,820	7,580	7,610	4,700	4,300	2,700	3,200	1,340	1,830
6.	Zange	3,570	3,780	4,300	4,660	3,530	3,780	2,080	2,630	1,430	1,630	990	1,380
	Total	**35,114**	**35,430**	**36,540**	**36,134**	**26,906**	**27,846**	**32,000**	**31,900**	**11,760**	**11,210**	**7,404**	**7,580**

Source: Fieldwork, 2019

***Note**: Qty. Sup = Quantity Supplied; Qty. Used = Quantity Used*

Conclusion

The study shows that most households sampled in the six (6) wards of Dukku L.G.A rely on various sources of water. Majority 90% of the household used wells, streams, and rivers for water supply. Some households trek more than 10km to fetch water. The quantities of water used for domestic activities outweigh the quantities supplied. The variations for water obtained in liters from different sources were due to seasonality of streams, rivers and ponds and tastiness of borehole and well water that are only good as supplement for domestic drinking and cooking purposes. In general, Dukku L.G.A had a serious problem concerning domestic water use because its per-capital water consumption level is grossly inadequate as compared to the internationally accepted standards for rural areas.

Recommendations

In view of the findings of the research, the following recommendations have been made:

i. The government and other development actors should aid the community by drilling more boreholes. This would help to increase the sources of and accessibility to water in the area, which is essential to addressing the water scarcity issue. Providing more boreholes would ensure that people have more options for accessing water, and it would help to reduce the distance that people must travel to fetch water.
ii. Households in Dukku LGA should be educated on water management to avoid waste and ensure sustainability of water sources. Hence, the need to raise awareness about the importance of responsible water usage and conservation. By educating households on proper water management practices, such as fixing leakages and using water-efficient appliances, households can conserve water and reduce waste. This would help to ensure the sustainability of water sources in the area and would help to reduce the demand for water.
iii. The importance of creating awareness about waterborne diseases and the need to use clean water for bathing and drinking. There is the need to educate the people about the health risks associated with consuming or using contaminated water. By creating awareness about waterborne diseases and promoting the use of clean water for bathing and drinking, the incidence of water-related illnesses in the area can be reduced.
iv. The state government and Dukku LGA should develop plans for obtaining regular supply from a more permanent source. There is the need for a long-term solution to the water scarcity problem in the area. By obtaining a regular supply from a more permanent source, such as a river or a reservoir, the community can have access to reliable and sustainable water supply. This would help to reduce the pressure on existing water sources and ensure that the community has access to clean and safe water.

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Biodiversity Loss And Environmental Sustainability Dilemma: Exemplum Of Ibesikpo Asutan Local Government Area Of Akwa Ibom, Nigeria

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Abstract : *This study examined the effects of human activities on biodiversity loss and its implications on environmental sustainability in Ibesikpo Asutan, Akwa Ibom State. A random sample of 460 households drawn from 23 villages was used for the study. Semi-structured interview and structured questionnaire were used for data collection on the degree of biodiversity loss and human activities in the area. Multiple Regression Technique was employed to generate Predictive models to predict change in biodiversity using the dominant human activities as predictors. Findings highlighted the significant contribution of farming and fuel wood harvesting to the loss in biodiversity in the area. Furthermore, it was revealed that the surge in the traditional local livelihood is bound to exacerbate biodiversity loss unless effort towards conservation and change in livelihood pattern are accelerated. Based on these findings, it was recommended that modern economic ventures should be provided for local people to reduce their over reliance on biodiversity exploitation for survival.*

Key words: Environmental; Biodiversity; Sustainability; Human Activities; Ibesikpo Asutan.

CITATION:
James, E. E.,Essien, A. E. and James, U. E. (2023). Biodiversity Loss and Environmental Sustainability Dilemma: Exemplum of Ibesikpo Asutan Local Government Area of Akwa Ibom, Nigeria. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 149-156

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Introduction

Biodiversity loss refers to the decline or disappearance of biological diversity, that inhabit the planet, its different levels of biological organization and their respective genetic variability, as well as the natural pattern present in ecosystem (Roe, 2019). Biodiversity loss is among the top global risks to society. The planet is now facing its sixth mass extinction, with consequences that will affect all life on Earth, both now and for millions of years to come (OECD, 2019). Humans have destroyed or degraded vast areas of the world's terrestrial, marine and other aquatic ecosystems. Natural forests declined by 6.5 million hectares per year between 2010 and 2015 and natural wetlands declined by 35% between 1970 and 2015. Over 30% of corals are now at risk from bleaching, and 60% of vertebrate populations have disappeared since 1970. These striking changes are driven by land-use change, over-exploitation of natural resources, pollution, invasive alien species and climate change. They are occurring in spite of international efforts to conserve and sustainably use biodiversity (OECD 2019), Human pressures

are undermining the biodiversity that underpins all life on land and in water. Ecosystem services delivered by biodiversity, such as crop pollination, water purification, flood protection and carbon sequestration, are vital to human well-being.

Biodiversity faces threats, including land-use change, habitat loss and fragmentation (e.g., due to agricultural expansion), over-exploitation of natural resources (e.g. unsustainable logging, hunting and fishing), pollution (e.g., excess fertilizer use and marine litter), invasive alien species and climate change (Butchart, 2020). For example, an analysis of over 8 500 threatened or near-threatened terrestrial, freshwater or marine species showed that 72% are overexploited, and 62% are affected by agriculture (crop and livestock farming), timber plantations and/or aquaculture (PBES, 2018). Agricultural expansion and intensification continues to be the dominant pressure on terrestrial biodiversity, and is expected to increase as the demand for food and bioenergy grows (Butchart, 2020). These impacts are exacerbated by international trade, which tends to shift the environmental impacts of production from developed to developing countries. For example, 33% of biodiversity impacts in Central and South America and 26% in Africa are driven by consumption in other regions (Marques, 2019).

Humans have transformed the majority of terrestrial, marine and other aquatic ecosystems across the globe. Ecosystems and the habitats they provide continue to be converted, degraded and fragmented, altering their function, productivity and resilience. Global forest cover continues to decline as demand for food and land increases (Scot, 2019). Planted forests have increased, but this increase has been offset by a decline in natural forests (FAO, 2019), which tend to be more diverse. Natural forest area declined by 10.6 million hectares per year from 1990 to 2000, and by 6.5 million hectares per year from 2010 to 2015 (FAO, 2019). Natural wetland coverage has declined by an estimated 35% over 1970-2015 and continues to decline at a rate of 0.85-1.6% per year. The fragmentation of forests, wetlands and other habitats is also increasing, as it is a precursor of species loss and disruption of ecosystem functions. Habitat fragmentation is expected to become increasingly problematic with climate change, as it undermines the ability of species to track suitable habitats (Bennet, 2017). The production of food is the primary cause of biodiversity loss globally. On land, the conversion of land for agriculture and the intensification of agriculture reduce the quality and quantity of habitat available. Food production also has negative impacts on freshwater wildlife (PBES, 2019), (through water extraction and the reduction in water quality resulting from soil and farm chemical run-off). Downstream pollution, especially from fertilizers, also damages marine systems. The wildlife of marine systems is also heavily affected by fishing and in various ways by fish and shellfish farming. Over the past 50 years, the biggest driver of habitat loss has been the conversion of natural ecosystems for crop production or pasture. (PBES, 2019), the area of land occupied by agriculture has increased by around 5.5 times since 1600 and is still increasing. Currently, cropping and animal husbandry occupy about 50 per cent of the world's habitable land (Rands, 2019).

The dramatic loss of biodiversity brings serious risks for societies, economies and the health of the planet. Biodiversity loss has also threatened the foundations of economy: one attempt to put a monetary value on goods and services provided by ecosystems estimates the worth of biodiversity at US$33 trillion per year close to the GDP of the United States and China combined (Bos, 2017). Some of the loss of biodiversity undermines ecosystems ability to function effectively and thus undermines nature's ability to support a healthy environment. Implications arising from

biodiversity loss include: food insecurity, health risk, exacerbation of climate change, exacerbation of climate change, Business risk, indigenous community livelihood and culture risks, Insect decline (PBES, 2019).

Ibesikpo Asutan is among the richest, endowed and diverse ecological community in Akwa Ibom State. It occupies the coastal hinterland and freshwater swamp zone lying in the middle belt of the State. The fresh water and the adjoining swamp forest is home to biodiversity making it an area of high significance to the people. The area is part of the reserved territory meant to preserve and conserve the different species of animals, and plants that were facing extinction. The forest also serves as a buffer zone against the waves and storms to the hinterland.

However, in recent times, there has been increasing human activities in the area as a result of high economic value of the ecological resources. The local communities within the area engage wholly in activities like fishing, palm wine tapping, farming, hunting, and logging for survival. These activities have directly impacted on biodiversity and the sustainability of the environment. Essentially, the study is designed to examine the status of biodiversity loss and the extent to which human activities contribute to biodiversity loss in the area.

Materials and Methods

Ecological properties of Ibesikpo Asutan

Ibesikpo Asutan is one of the 31 Local Government Areas in Akwa Ibom State. It lies between latitudes $4^{0}32^{1}$ and $5^{0}33^{1}$ North and longitude $7^{0}25^{1}$ and $8^{0}25^{1}$ East. It is bounded on the North by Uyo Local Government Area on the South by Nsit Ubium, East by Uruan and on the West, by Nsit Atai Local Government Area (Fig. I), Cartography Directorate, Bureau of lands, Caribbean Development Info (1997).

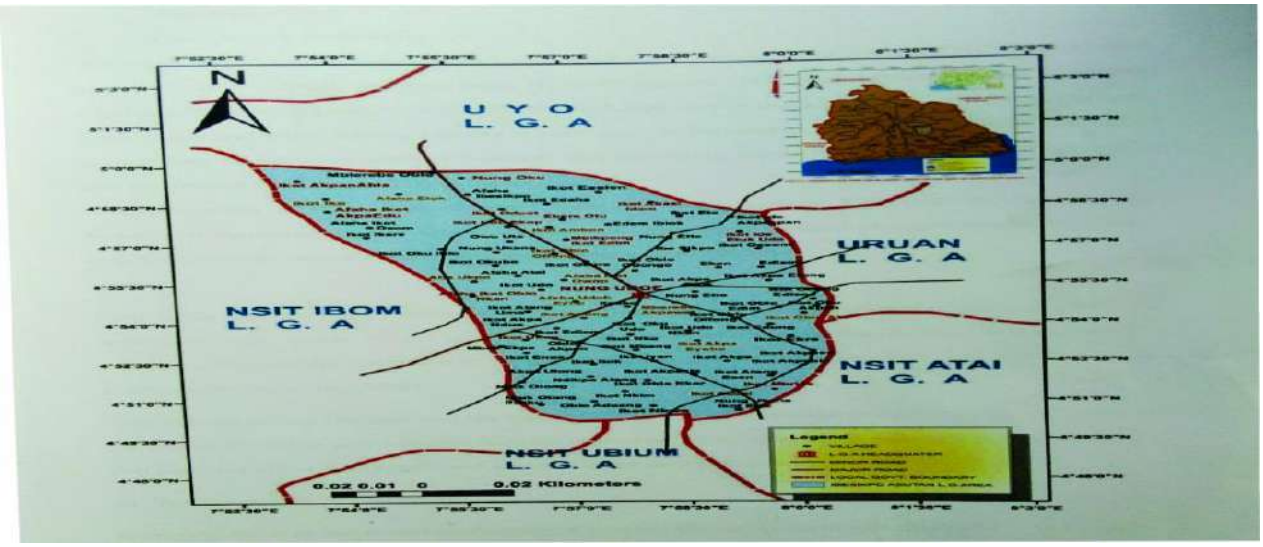

Fig. I: Ibesikpo Asutan LGA and its boundaries
Source: Geography Department, Uniuyo

According to Udoh and Essien (2015), Ibesikpo Asutan belongs to the coastal hinterland and fresh water swamp ecological zone that lies in the middle belt of the state. It is characterized by a low- lying undulating plain, with a predominant vegetation of grass plain, palm swamps, scrubs and forest on water logged and seasonally flooded soil. The area has a mean animal rainfall of 2148mm as well as a mean temperature and relative humidity of $30.8^{0}C$ and 75.2% respectively. The area boasts of diverse species of animal and plants that are now being threatened due to increased human activities.

Sample and Sampling Technique

The study used a sample of 23 villages drawn from a population of 79 gazette villages in Ibesikpo Asutan Local Government Area. This represents 30% of the total villages. Furthermore, out of the total population of 944 households in the 23 selected villages, the study used a sample of 460 households (representing 48.7%). In each village, 20 households were randomly selected for questionnaire administration. Furthermore, from each village, two community leaders, one youth and women leaders were purposively chosen for interview regarding the status of biodiversity loss.

Data Requirement and Sources

Two sets of data were sourced for the study. They include:

Table 1: Dependent Variables

Types of biodiversity	Level of biodiversity loss
i. Wild life	High (3), moderate(2), low(1)
ii. Insects	High (3), moderate(2), low(1)
iii. Food plant	High (3), moderate(2), low(1)
iv. Herbs	High (3), moderate(2), low(1)
v. Trees	High (3), moderate(2), low(1)

a. Data measuring the volume of human activities as independent variable are as follows:

Table 2: Independent Variables

Types of activities	unit of measurement (Population)
X_1 Hunting	No. of households involved
X_2 Lumbering	No. of households involved
X_3 Farming	No. of households involved
X_4 Fire wood harvesting	No. of households involved

b. Data measuring the level or status of biodiversity loss (representing the dependent variables) are
c. as follows:

Data for the dependent variables, that is, level of biodiversity loss was collected through interview with community leaders, and elders in the area. During the interviews, they were asked to rank the level of biodiversity loss in their communities on a 3- point rating scale of 3- high, 2- moderate and 1- low, while data for the independent variables. Volume/population of human activities was collected from responses elicited in the questionnaire administered to heads of sampled households in each the selected villages.

Data Analysis

Multiple Regression analysis was utilized to examine the contributions of the independent variables (human activities) to change in biodiversity (dependent variable) in the study area. The Multiple Regression is a parametric Statistics designed for modeling change in a dependent variable using two or more independent variables. As a parametric test, it is sensitive to data abnormality and non-linearity which were surmounted by standardization.

Results and Discussion Status of Biodiversity Loss in the Study Area

The responses generated from the rating of levels of biodiversity loss by the community leaders for each sampled community is

presented in Table 3. A 3-level rating scale where 3 indicated high level loss; 2 – indicated moderate and 1- indicated low level of biodiversity loss, was used to assess the level of biodiversity loss. However, the summaries are presented in Table 4.

Table 3: Rating of Level of Biodiversity Loss in the sampled communities

S/N	Sampled Communities	Insect	Wildlife	Food plant	Herb	Trees
1	Ikot Iko	3	3	3	3	3
2	Ikot Obio Offong	3	3	3	3	3
3	Ikot Oduot	3	3	3	3	3
4	Ikot Mbride	3	3	3	2	3
5	Aba Ukpo	3	3	2	2	3
6	Ikot Anung	2	3	2	2	3
7	Ikot Abasi	3	3	3	3	3
8	Ikot Obio Ata	3	3	3	3	3
9	Ikot Udo Ekpo	2	2	2	2	3
10	Ikot Udo Eyoho	2	2	2	2	3
11	Afaha Ikot	3	3	3	3	3
12	Ikot Ambon	3	3	3	2	3
13	Ebere Otu	3	3	3	3	3
14	Mbierebe	3	3	3	3	3
15	Afaha Ikot	1	1	2	2	3
16	Ikot Ide	3	3	3	2	3
17	Ikot Ukop	3	3	3	1	3
18	Ikot Abasi Idem	1	3	1	1	3
19	Nung Oku	3	3	1	1	3
20	Afaha Etok	3	3	3	3	3
21	Ikot Akpan Abia	3	3	1	3	3
22	Mbikpong Ikot Edim	3	3	3	3	3
23	Afaha Ikot Owop	3	3	3	3	3

N/B: 3 indicates high rating; 2- Moderate and 1- Low rating (Source: Authors Field Work (2022))

Table 4: Summary of Biodiversity Loss in the Study Area

Type of Biodiversity	No. of Villages reporting High level of biodiversity loss	No. of Villages reporting moderate level of biodiversity loss	No of Villages reporting low level of biodiversity loss	Total
Insect	18 (78%)	3 (13%)	2 (9%)	23 (100%)
Wild Life	20 (87%)	2 (9%)	1 (4%)	23 (100%)
Food Plant	15 (65%)	5 (22%)	3 (13%)	23 (100%)
Herbs	12 (52%)	8 (35%)	3 (13%)	23 (100%)
Trees	23 (100%)	0 (0%)	0 (0%)	23 (100%)

Source: Culled from Table 3

As data in Table 4 indicated, a high loss in insect was reported in 18 out of 23 sampled villages representing 78 percent of total villages. Similarly, 20 villages (representing 87%) reported high loss in wild life; 65% of villages reported high loss in food plants, 52% for herbs

while 100% of communities reported high loss in trees. From the forgoing, it is clear that wildlife and trees species represent the most endangered type of biodiversity in the area. The proceeding section displays the dominant human activities in the area and the degree of impact they have on biodiversity.

3.2 **Dominant Human Activities in the Area and their Contribution to Decline in Biodiversity**

Table 5 displays the major types of human activities and the number of households engaged in it. Accordingly, farming remains the dominant human activity with 69.5% of households involved in it. 17.5% of households were involved in firewood harvesting while 8.6% and 4.4% were involved in hunting and lumbering activities respectively.

Table 5: Dominant Human Activities in the Study Area

Human Activity	No. of Households Involved	Percent of total
Farming	320	69.5
Firewood Harvesting	80	17.5
Hunting	40	8.6
Lumbering	20	4.4
Total	460	100

Source: Authors' Field Survey (2022)

Furthermore, the relative contribution of these human activities to loss in biodiversity was examined using the Multiple Regression. Results as displayed on Table 6 shows the model summary as well as the Beta Co-efficient for predicting biodiversity loss for insect (Y1); wildlife (Y2); food plants (Y3); Herbs (Y4) and trees loss (Y5) using the human activities: Farming (X_1); Hunting (X_2); Lumbering (X_3) and Fire wood harvesting (X_4) as predictors. As data in Table 6 indicated, human activities related strongly with insect loss (R = .804) and explained 64.6% of the change in insect population (R^2 = .646) in the area. However, the relative contribution of the predictors showed that farming (X_1) made the strongest impact on insect loss in the area (Beta = .994). Essentially, the model for predicting insect loss in the area is given as: $Y_1 = .23.22 + .994\ x_1 + .508x_2 + -.592x_3 + .654x_4 + 15.73$. For wildlife loss, results showed that human activities correlated strongly (R= .793) with wildlife loss and explained up to 62.9% of variance (R^2 = .629). Similarly, farming activities and hunting contributed significantly to the loss in wildlife. The equation for predicting change in wildlife is as follows: $71.74 + 1.501x_1 + .756x_2 + .254x_3 + .485x_4 + 3.024$

For loss in food plants, results showed a strong positive correlation between human activities and food plants loss. Furthermore, human activities explained up to 36.9% of the change in food plants. The model equation is given as: $-29.83 + .801x_1 + 1.757x_2 + .257x_3 + .776x_4 + 14.17$. In terms of explanation for herbs loss, human activities explained up to 36.4%. However, the beta co-efficient indicated that farming made the strongest contribution on Herbs decline. The equation for predicting Herbs loss is given as $70.31 + - .342x_1 + -.063x_2 + -.044x_3 + .106x_4 + 19.48$

Regarding tree loss in the study area, a strong correlation was found between tree loss and human activities (R=.901) as the R^2 derived as .791 implies that human activities explained up to 79.1% of the loss in trees in the study area. However, farming activities, lumbering and fire wood harvesting contributes highly to the loss in trees. The model for predicting tree loss in the area is given as: $117.41 + 1.757x_1 + .531x_2 + 1.419x_3 + .966x_4 + 21.36$. The implication of findings is discussed in the proceeding section.

Table 6: Regression Models for Predicting Biodiversity Decline in the Study Area

Type of biodiversity	Model Summary				Beta Coefficient for the Predictors				Parameters
	R	R^2	Std. Error	Sig.	Farming X_1	Hunting X_2	Lumbering X_3	Firewood X_4	Constant
Y_1 = Insect	.804	.646	15.733	.002	.994	.508	-.572	.654	23.22
Y_2 = Wildlife	.793	.629	3.024	.003	1.501				
Y_3 = Food Plant	.607	.309	14.178	.008	.560				
Y_4 = Herbs	.603	.364	19.481	.004	-.342				
Y_5 = Trees	.901	.791	21.364	.000	1.757				

Source: Authors' Analysis (2022)

Implication of findings on Environmental Sustainability

The need to use environmental resources in a responsible manner that guarantees health and wellbeing of present and future generations is the hallmark of environmental sustainability. The situation in the study area is far from being sustainable. Findings have identified human activities – particularly, farming and firewood harvesting as the major triggers of biodiversity loss in the study area. Farming is unarguably the economic main stay of the locales and is by far the most significant contributor to loss in trees, food plants, insects, herbs and wild life in the area. Population increase fuels the crises of livelihood struggle and increase the pressure on land resources. There is a steady increased demand for arable land which has engendered significant land cover change – converting forests to farm lands. The quest for more agricultural land creates a chain reaction on biodiversity as wildlife; trees, food plants and the insect population are displaced or totally destroyed. There are far grave repercussions for the future generation if there is no deliberate and well-targeted effort at conservation and change in livelihood pattern in the area. Furthermore, the current energy crises have re-engineered the demand for fuel wood thereby making firewood harvesting a major driver of biodiversity loss, particularly loss in trees. The wanton felling of trees in the area portends serious natural disaster like wind storms in the short run and global warming in the long run. If this trend continues, more forests will be "sacrificed" at the expense of sustainability. The predictive models generated for the study area affirm the fact that given the current trend in livelihood struggle – particularly farming and fire wood harvesting, the remaining forests in the area will be extinct in the shortest future. This indeed will portend environmental catastrophe for the study area. The findings are in line with previous studies in Eket, Akwa Ibom State, where the uncontrolled exploitation of environmental resources, particularly groundwater and vegetation were identified as the major health risk factor for residents in the area (James, Essien and Etim, 2019).

Concluding Remarks

The choice between activating the traditional livelihoods (farming, hunting, lumbering, firewood harvesting, fruit harvesting and palm wine tapping) and conserving natural resources such as the forests will continue to pose a dilemma for resources managers in this dispensation. This study has shown that continuing in the traditional livelihood indulgence can be detrimental to environmental sustainability in the 21st Century. The price of losing the forests, wild life, insect species, food plants and herbs quite outweighs the chances of change in livelihood pattern for local society. There is need to shift from over-relying on land resources to sustain local population to creating modern livelihood schemes for local people. It is clear that the surge in population is bound to exacerbate the pressure on local resources – particularly the forest except there is a deliberate effort towards conservation and modernization of livelihood pattern. Based on these facts, it is hereby recommended that deliberate effort towards diversifying local economies by creating modern ventures will

help to reduce over dependency on biodiversity exploitation.

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Application Of Biotechnology In Environmental Protection

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Abstract : *Environment may be defined as the sum total of all living and non-living elements and their effects that influence live of humans, animal and plants. It encompasses the interactions of all living species, climate and natural forces that affect human survival and economic activities. It provides a wide range of benefits such as the air we breathe, the food we eat and the water we drink, as well as the materials needed in our homes, at work and for leisure activities. The environment is a very important component for the existence of man, plants and animals. Despite these immense benefits from the environment, it has been threatened by natural and anthropogenic activities such as flood, storms, earthquakes, volcanic eruptions; burning of fossil fuels, poor sewage and waste disposal systems and mining which together have resulted in environmental degradation. These immense threats can be eradicated through the application of biotechnology such as bioremediation, biofiltration and biomonitoring.*

Keywords: Environment, environmental degradation, environmental protection, biotechnology, environmental education

CITATION:

Akpan, M. P., Emmanuel, B. and Utuk, U. J. (2023). Application of Biotechnology in Environmental Protection. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 130-148

Introduction

Environment refers to nature in which plant, animal, man and other physical elements exist on. It is the basic life support system which is composed of living and non-living things, physical surroundings and their climatic conditions (Gandhi, 2018). Environment is variable and difficult to predict and manage, this in turn leads to environmental problems which occur as a result of human and natural activities. Humans and natural activities affect the environment and its biodiversity by producing and adding contaminants to land, water and air thereby changing land use and natural fluxes and cycles of energy thus reducing the habitats of such species even resulting in succession and extinction (Eccleston, 2010). Dealing with these problems would require system new and integrated multidisciplinary approaches. These approaches include bioremediation, biomonitoring, biofiltration, biofertilization and other environmental management techniques (Daniel, 2010).

The increasingly environmental degradation requires joint efforts of individuals, NGOs and governments of both State and Federal on environmental protection and awareness for sustainable development. Therefore, a healthy and sustainable environment is the one that provides vital goods and services to humans as well as other organisms within the ecosystems (Jing *et al.,* 2013). This can be achieved in two ways which include discovering ways of reducing negative human impact on the environment and

enhancing the well-being and vitality of all living organisms (plants and animals) in the environment (Jing *et al.,* 2013). Almost one quarter of the global diseases may be attributed to environmental factors, so improving our nations understanding of the effects of the environment on health and well-being is very crucial. Without this understanding, environmental degradation can affect human health directly through the exposure to water/air and land pollution, heavy metals, and synthetic chemicals and indirectly through loss of biological controls in favour of opportunistic agents and vectors of disease. These problems have affected the environment negatively especially with the absence of environmental protection leading to serious ecological damage (Chen *et al*., 2005). These problems or changes in the environment can be managed through the application of the biotechnology (Daniel, 2010).

Biotechnology is not a new approach, it has been used to resolve environmental degradation across the world, and this results in the production of biological agent or products (Chen *et al*., 2005). Generally, biotechnology is a field of biology that involves the production and use of living materials or biological products to generate new products for use in resolving problems in medical, agricultural, pharmaceutical and environmental systems. Therefore, modern biotechnology has enormous potentials for improving human welfare in areas ranging from food processing to human health and environmental protection. The ultimate goal of biotechnology is to benefit humanity and the environment. The use of biotechnology in environmental protection is one of today's fastest and most practically useful approaches. The aim of biotechnology is to prevent arrest and reverse environmental problems for the sustainability and conservation of the ecosystem. This also helps in the protection of the integrity of the environment with a view to acquiring a long-term ecological security (Daniel, 2016).

Environmental Degradation

Environmental degradation is the deterioration of environment through the depletion of resources such as air, water and soil; the destruction of the ecosystem including the extinction of wildlife and pollution. Environmental degradation comes in many ways that is when natural habitats are destroyed or natural resources depleted then the environment is said to be degraded. Efforts to counteract these issues are through environmental protection and management. The Amazon makes up 60% of all rainforests and its deforestation poses major impacts on the world around. Through constant cutting down of trees, the production and release of oxygen is reduced which is detrimental to health. An additional result from this land degradation are erosion and gullies. Land degradation is the reduction or loss of biological or economic productivity and complexity of rain-fed crop land, or range, pasture, forest or woodland resulting from natural processes, land uses or human activities and habitation patterns such as land contamination, soil erosion and destruction of the vegetation cover. Thirty –three percent of the global land area is being degraded (FAO, 2015). Globally forest and crop production account for approximately 18 percent of the global total degraded land (Bal *et al.,* 2008). The main causative factors of land degradation is unsustainable land use practices such as excessive use of chemical fertilizer and mono-cropping, deforestation and vegetation cover change and loss, soil erosion due to poor soil management practices such as over cultivation of soils or over grazing, pollution (that is air, soil and water caused by poor management practices), climate change and international economic practices example extractive industries (Naseer and Pandey, 2018). Land degradation leads to loss or reduction in

biological production of land which has greater effects on ecosystem functioning (UNCCD, 2019). Efforts to counteract these issues are through environmental protection and management.

Climate Change/Global Warming

Climate change is the periodic alteration of the atmosphere. Earth's climate is brought about as a result of changes as well as interactions between the atmosphere and various geologic, chemical, biological, and geographic factors within the Earth system (Jackson, 2021).

Climate change, also called global warming, refers to the rise in average surface temperatures on Earth (Jackson, 2021). This is as a result of the primarily use of fossil fuels by humans, which releases carbon dioxide and other greenhouse gases into the air. The gases trap heat within the atmosphere, which has a range of effects on ecosystems, including rising sea levels, severe weather events, and droughts that render landscapes more susceptible to desertification, erosion and wildfires. Other human activities, such as agriculture and deforestation, also contribute to the proliferation of greenhouse gases that deplete the ozone layer and cause climate change. These also threatens people with food insecurity, water scarcity, flooding, infections, extreme heat, economic losses and displacement (WHO, 2015).

Pollution

Pollution is the introduction of contaminants into the natural environment that causes adverse change. Pollution can take the form of chemical substances or energy such as noise, heat or light. Pollutant, can be either foreign substances/energies or naturally occurring contaminants. Major forms of pollution include water, air, soil contamination and many others (Laura, 2018). These forms of pollution come from natural and anthropogenic sources. Pollution comes from human activities such as combustion, construction, mining, agricultural activities or production, oil spillage and exploitation, factories/ industries, smoke, carbon dioxide from burning fires. Pollution endangers the activities of earth support system and threatens the continuing survival of human activities.

Water pollution is the contamination of water bodies as a result of human activities in such manner that negatively affect its legitimate uses (Von, 2015). Water pollution results from the release of contaminants (organic/inorganic) into the natural environment. These pollutants include; detergents, food wastes, insecticides. pesticides, heavy metals from motor vehicles, fertilizers, trash or garbage (Moss, 2008). The causes of water pollution also include a wide range of chemicals and pathogens and well as physical parameters. Natural phenomena such as algae, blooms earthquake and volcanoes among others, release chemicals which cause changes in water quality and ecological status of water (West, 2006). Air pollution is the presence of substances in the atmosphere that are harmful to the health of humans and other organisms or to environment. Sources of air pollution include gases such as ammonia, carbon dioxide, carbon monoxide, sulphur dioxide, methane among others. These gases cause diseases, allergies and even death to humans and other organisms such as animals and plants, causing damage to the environment. Both human activities and natural processes can generate air pollutants.

Causes of Environmental Problems

Human activities have been known to cause serious effects on the environment from the time of our very earliest ancestors. Since *Homo sapiens* first walked on earth, the environment around us has undergone changes through agriculture, urbanization and commercial activities. At present, human impact on the environment is so substantial that scientists believe ecosystems untouched by humans, no longer exist in the world. Therefore, some of the causes of the environmental problems include;

oil spillage, refuse dumps on land and water, smokes from vehicles and generators, burning of fossil, mining, poor sewage disposal, volcanic eruptions, floods, droughts, release of industrial wastes and hurricanes, tornados and tsunamis. Our civilization pleads for protection against environmental degradation.

(i.) Oil Spillage and Exploit

Fig. 1: Oil spillage in Niger Delta (Source; https://www.en.m.wikipedia.org)

Oil spills is a common event in the Niger Delta of Nigeria (Baird, 2010). Corrosion of pipelines and tankers result in the rupturing or leakage of oil from production infrastructures that often do not receive regular or consistent inspection and maintenance (Nwilo, 2001). There is an extensive network of pipelines between the oil fields as well as numerous small networks of flow lines to different directions and depots spread about the country. The pipes carry oil from wellheads to flow stations through pressure which cause the pipes to rust thereby creating opportunities for leaks. In onshore areas, most pipelines and flow lines are laid above ground and are often vandalized. Pipelines, have an estimated life span of about fifteen years, and so are susceptible to corrosion after a prolonged use. Most of the pipelines are as old as twenty to twenty-five years and have not been changed due to high cost of replacement and this result in oil spillage (Bronwen, 2007). Oil Spills in populated areas often spread out over a wide area, leading to the destruction of crops and aquatic organisms through contamination of the groundwater and soils which is as a result of careless oil operations in the areas (Illing, 2019). This also has an effect on humans living in such areas leading to health issues including breathing problems and skin lesions. Oil spills and leaks during extraction or transportation can also pollute drinking water sources and jeopardize entire freshwater or ocean ecosystems (Baird, 2010).

Burning of Fossil Fuel

Coal, crude oil, and natural gas are all considered fossil fuels because they were formed from the fossilized, dead and buried remains of plants and animals that lived millions of years ago. Because of their origins, fossil fuels have high carbon content. Fossil fuels emit harmful air pollutants when they are burned. This is as a result of large quantities of carbon monoxide formed from fossil fuels when burned. Furthermore, fossil fuels powered by cars,

trucks, ships, and boats are the main contributors of poisonous carbon monoxide and nitrogen oxide, which produces smog (and respiratory illnesses) on hot days. When oil, coal, and gas are burned and gas passed into water, it changes the ocean's basic chemistry, making it more acidic and poisonous to aquatic lives. As the acidity in our water goes up, the amount of calcium carbonate, a substance used by oysters, lobsters, and countless other marine organisms to form shells go down. This slows down growth rates, weaken shells, and impairs entire food chains thus having an effect in the aquatic environment (Kopp, 2021). In effect, the burning of fossil fuels has many negative environmental impacts which extend beyond the people using the fuel. The actual effects depend on the types of fuel in question. Burning coal, oil and its derivatives, also contribute to atmospheric particle matter, smog and to acid rain which is already negatively impacting the ecosystems (Michael, 2018). The figure below shows the environment where fossil fuel is burned on continuous bases. In the Niger Delta Region of Nigeria, burning of fossil fuel has continued unabated despite the enactment of laws forbidding it.

Fig. 2: Source: Jim Getty, 2015

(ii.) Mining Activities

Mining operations produce acids and particles which runoff into streams, rivers, and lakes and dump vast quantities of unwanted rock and soil into streams thereby block up water source. Impacts can result in erosion, sinkholes, loss of biodiversity, or the contamination of soil, groundwater, and surface water by the chemicals emitted from mining processes. These processes also have an impact on the atmosphere from the emissions of carbon which have effect on the quality of human health and biodiversity (Laura, 2018). Mining activities can have serious negative effects on the environment, these effects occur from the exploration stage to the closure stage of a mine's operation. Hundreds of tons of rock are unearthed, moved, and crushed in mining operations which significantly increases the amount of dust and particulates in the air. In addition, mine tailings, which may contain finely ground and even toxic waste, can become airborne. Metal mining generates hundreds of millions of pounds of hazardous waste each year, but because of a loophole in the federal Resource Conservation and Recovery Act, mining waste is exempted from the special handling and treatment normally required for hazardous wastes. Metal Mining annually produces more toxic waste by volume than any other industry in the United States. For example, as at 2001, the metal mining industry reported

2.8 billion pounds of toxics emitted to air, water, and land or 45 percent of all industry-emitted toxics (EPA, 2000). Mining is often a heavy industrial activity that involves road construction and the use of heavy machinery, causes severe damage to environment as well as wildlife. Since the birth of the industrial revolution, man has continued to introduce hazardous materials into her environment at an alarming rate. These materials mostly consisting of inorganic substances (heavy metals) which pose serious health and environmental threat. In mid 1990s, it was reported that on an annual basis, about 700 million kg of metals in mine tailings were disposed on land globally (Warhurst 2000). Mineral exploration and processing have caused varying degree of environmental damage in Nigeria. These include alteration of ecological state, air, water, soil pollution, destruction of soil flora and fauna, loss of vegetation, landscape degradation and radiation emission (Oramah *et al.,* 2015). The present health challenges such as dizziness, kidney pain, respiratory problems, miscarriages and deaths and associative costs in communities are all linked with records of mining activities (Twerefou *et al.,* 2015). Figure (3) below shows mining operations in Nigeria. The workers have no protective materials while at work and are exposed to hazards which can endanger their health and reduce life expectancy.

Fig. 3: Mining activities in Nigeria (Source: https://www.plustvafrica.com)

Poor Sewage/Waste Disposal

Sewage is an important consideration for every part of the world. Simply put, it's water-carried waste. Whether it's the stuff that leaves your toilet, or the vast amounts of wastewater that flow out of industrial plants – everyone contributes to it and so must be collectively dealt with to have a safe environment. However, if sewage is only partially treated before it is disposed of, it can contaminate water and harm huge amounts of wildlife. Alternatively, leaking or flooding can cause completely untreated sewage to enter rivers and other water sources, causing them to become polluted.

Various methods of sewage disposal are adopted in different cities in Nigeria. These methods include the use of septic tanks, flow of sewage into storm water drainages, open ground, water ponds and streams (Ajibuah and Terdoo, 2013). In Katsina metropolis where decentralized system is practiced, all of these methods are adopted but the use of septic of tanks causes ailment on human health resulting from unpleasant smell from cleared drainages which

pollutes the air people breathe in and make them uncomfortable in their homes. It's accumulation of stagnant water serves as home for mosquitoes and other dangerous animals to breed (Alghobar and Saresha, 2015). Indiscriminate waste disposal has adverse effect on health and longevity. In situations where wastes are disposed into drainage system or water channels, the free flow of water becomes hindered when it rains which leads to an over flow of the water channel which sometimes give rise to flooding (Ajibuah and Terdoo 2013). The figure below shows the discharge of sewage into waterways.

Fig. 4: Sewage disposal on water (Source; https://www.aboutcivil.org.)

Fig. 5: Refuge dump on lands (Source: hhtps://www.ecobarter.com.ng)

Fig. 6: Refuse dumps on water and water sides (Source: htpps://www.pinterest.com)

Smokes from Vehicles

Smokes from vehicles can valuably air at the surface and cause smog which obstruct visibility. Particulate presents significant health issues to man. Smokes from car are also one of the major causes of global warming. Cars air conditioners and trucks emit carbon dioxide and other greenhouse gases, which contribute one-fifth of the United States' total global warming pollution.as a result of the pollution that is created from toxic and dangerous materials into our environment, not only does the planet's ecosystem come under threat, but our own health is potentially at risk too (Lahieb *et al*., 2020).

Fig. 7: Smokes from cars (Source: https://www.gomechanic.in)

Earthquakes

Earthquakes are caused by the sudden release of energy within some limited region of the rocks of the Earth. Earthquakes occur most often along geologic faults, narrow zones where rock masses move in relation to one another. The energy can be released by elastic strain, gravity, chemical reactions, or even the motion of massive bodies. Of all these the release of elastic strain is the most important cause, because this form of energy is the only kind that can be stored in sufficient quantity in the earth to produce major disturbances (Bolt, 2021). Furthermore, an earthquake is the result of trembling, rolling and vibration of the ground triggered by the sudden release of energy that is stored below the surface of the Earth. In the following countries like China, Indonesia, Pakistan, Iran, United States, Japan, and the Philippines, there are a lot of earthquakes and they have numerous volcanoes. With these the three main causes of it includes tectonic plate movement, human activities, and volcanic eruptions. As a result of these, it destroys property and cause death (McNally, 2007). Building skyscrapers is also a good example that may cause an earthquake. Many engineers and scientists are concerned about the types of buildings in construction which have an effect on the environment. Also, for example, in the Rocky Mountains where there is a place for waste disposal. (Madrigal, 2008) The injection of fluids into deep wells causes changing of the stress of the underground and the stress can generate an earthquake. Furthermore, the release of pressure when extracting oil and natural gas can also cause earthquake. Based on these, it can have disastrous effects on humans and on the environment putting it at risk. Earthquakes can have disastrous effects on humans and on the environment (Presnell, 2002).

Fig. 8: The 2011 Tohoku earthquake, which was centred at a fault in the Pacific Ocean
Source: Nature Geo Sci (2018)

Flood

A flood is an overflow of water that submerges land that is usually dry. Human activities in the environment often increase the intensity and frequency of flooding, for example land use practices such as deforestation and removal of wetlands, blocking of waterway course or flood controls such as levees, and larger environmental issues such as climate change and sea level rise. Flooding may occur as an overflow of water from water bodies, such as a river, lake, or ocean, in which the water overtops or breaks levees, resulting in part of that water escaping its usual boundaries, or it may occur due to the accumulation of rainwater on saturated ground in an area. While the size of a lake or other bodies of water will vary with seasonal changes in precipitation and snow melt, these changes in size are unlikely to be considered significant unless the water covers property or drown domestic animals (Glossary of Methodology, 2002). Floods can also occur in rivers when the flow rate exceeds the capacity of the river channel, particularly at bends or meanders in the waterway. Floods often cause damage to homes and businesses if they are in the natural flood plains of rivers. Riverine flood damage can be eliminated by moving away from rivers and other bodies of water, people have traditionally lived and worked by rivers because the land is usually flat and fertile and because rivers provide easy travel and access to commerce and industry. Flooding can lead to secondary consequences in addition to damage to property, such as long-term displacement of residents and creating increased spread of waterborne diseases and vector-borne diseases transmitted by mosquitos (WHO, 2021).

Volcanic Eruption

Volcanoes pose a threat to almost half a billion people; today, there are approximately 500 active volcanoes on Earth, and every year there are 10 to 40 volcanic eruptions. Volcanic eruptions produce hazardous effects for the environment, climate, and the health of the exposed persons, and are associated with the deterioration of social and economic conditions. Along with magma and steam (H_2O), the following gases surface in the environment: carbon dioxide (CO_2) and sulphur dioxide (SO_2), carbon monoxide (CO), hydrogen sulphide (H_2S), carbon sulphide (CS), carbon disulfide (CS_2), hydrogen chloride (HCl), hydrogen (H_2), methane (CH_4), hydrogen fluoride (HF), hydrogen bromide (HBr) and various organic compounds, as well as heavy metals (mercury, lead, gold).Their

unfavourable effects depend on the distance from a volcano, on magma viscosity, and on gas concentrations. The hazards closer to the volcano include pyroclastic flows, flows of mud, gases and steam, earthquakes, blasts of air, and tsunamis. Among the hazards in distant areas are the effects of toxic volcanic ashes and problems of the respiratory system, eyes and skin, as well as psychological effects, injuries, transport and communication problems, waste disposal and water supplies issues, collapse of buildings and power outage. Further effects are the deterioration of water quality, fewer periods of rain, crop damages, and the destruction of vegetation. During volcanic eruptions and their immediate aftermath, increased respiratory system morbidity has been observed as well as mortality among those affected by volcanic eruptions (Zuskin *et al*., 2007).

Fig. 9: Flood in Niger Delta of Nigeria (Source: Field Survey, 2020)

Fig. 10: Poor disposal of the industrial base (Source: Jim Sugar, Getty (2015))

Biotechnology and environmental protection

Biotechnology is a broad area of biology involving the production and use of living systems and organisms to develop or make products, or "any technological application that uses biological systems, living organisms or derivatives, to make or modify products or processes for specific purpose. Biotechnology means the use of living organisms or biological processes developing useful agricultural, industrial, or medical products especially by means of techniques, such as genetic engineering, that involves the modification of genes. The word bio means life and technology the application or harnessing science for a specific purpose. The term is believed to be coined in 1919 by the Hungarian engineer KrolyEreky. The term biotechnology by this engineer means the production of products from raw materials with the aid of living organisms. Biotechnology has applications in four major areas, including health care (medical), agriculture, industry and environment. Allingham (2008) opined that in agricultural biotechnology, it applies to techniques used in livestock husbandry (nutrition and reproduction) and it also include the transformation of plants, crop species and varieties through genetic engineering techniques leading to what are known as genetically modified (GM) crops. Environmental biotechnology plays a role in protecting the environment, cleaning up environmental waste and pollution (Daniel, 2016). Another example is the use of bacteria by mining for bioleaching. In industries, biotechnology can be used for industrial purposes (industrial fermentation). It includes the practice of using cells such as microorganisms or components of cells like enzymes to generate industrial useful products in sectors such as chemicals, food and feed, detergents, pulp and paper, textiles and biofuels. A series of terms have been coined to identify several branches of biotechnology. Some of them include:

Green biotechnology is applied to agricultural processes. An example is the selection and domestication of plants via micro- propagation (Kafarski, 2012). This can be used to eradicate world hunger by using technologies which enable the production of more fertile and resistant crops against biotic and abiotic stress and ensures application of environmentally friendly fertilizers and the use of bio pesticides, it is mainly focused on the development of agriculture (Kafarski, 2012). In the other hand, some of the uses of green biotechnology involve microorganisms to clean and reduce waste (Aldridge, 2009). Yellow biotechnology refers to the use of biotechnology in food processing, for example in making wine, cheese, and beer by fermentation (Kafarski, 2012). It has also been used to refer to biotechnology applied to insects. This includes biotechnology-based approaches for the control of harmful insects, the characterization and utilization of active ingredients or genes of insects for research, or application in agriculture and medicine and various other approaches. Grey biotechnology, this type of biotechnology is dedicated to environmental applications, and focused on the maintenance of biodiversity and the remotion of pollutants (Kafarski, 2012).

Brown Biotechnology this is related to the management of arid lands and deserts. One application is the creation of enhanced seeds that resist extreme environmental conditions of arid regions, which is related to innovation, creation of modern agricultural techniques and management of resources (Kafarski, 2012).

Environmental Protection

Environmental protection can be defined as the prevention of unwanted changes to ecosystem and their constituents' parts, this includes; the protection of ecosystems and their constituents from changes associated with human activities and the prevention of unwanted natural changes to ecosystems (Jing *et al.,* 2013). These authors noted that from an ecological perspective, humans are regarded as an integral part of the ecosystem; therefore, separating human beings from nature can be artificial in which environmental protection is concerned with the relationship between people and the natural environment rather than the relationships between people and the communities. Enger and Smith (2010) noted that the objectives of environmental protection are to conserve the existing natural environment, where possible repair damage and reverse trends.

Environmental protection relates to preservation and conservation of environment. Preservation refers to the protection of ecosystem from damage, loss while conservation is greatly associated with the sustainable use of resources (Darnall *et al.,* 2008) It is now recognized that nature is not an optional luxury but an essential foundation for human well-being and sustainable development. The preservation and sustainable use of nature and its component is not a problem to be solved, but an integral part of a number of solutions such as the provision of water, security and sanitation, pollution control, improved livelihood, disaster risk reduction and mitigation, adaptation to climate change, among others (Pallangyo, 2007). Actions to ensure the conservation of the environment have to be integrated and mainstreamed into development schemes across all sectors to realize the UN sustainable Development Goals, including the actions undertaken under the remit of the International Plant Protection convention (IPPC) to achieve these goals.

The critical aspect of environmental protection is that it is driven by the values that human beings attribute to different aspect of the environment. These values need not to be instrumental, but the motivating factor of environmental protection is always the prevention of changes to the environment that humans do not want. This has an effect on human and the biophysical environment (Chunmei and Zhaolan, 2010). The primary objectives of environmental protection

is to restore an ecosystem or natural environment to it's previous state, which is associated with deliberate induced change as opposed to the prevention on change (Jing *et al*., 2013). Sustainable developments, ecological restorations alongside with animal welfare are not only all-important aspect when discussing conservation and change, but it is also providing a topic of concerns and awareness. By educating current and upcoming generations and equipping them with the necessary knowledge and tools, help replenish the environment to a healthier living, also societies are bound to reap great result through environmental protection (EPA, 2008).

Environmental Biotechnology

Gerben and Jerome (2005) define environmental biotechnology as the biotechnology that is applied to and used to benefit the natural environment. Vidya (2005) further described environmental biotechnology as "the optimal use of nature, in the form of plants, animals, bacteria, fungi and algae, to produce renewable energy, food and nutrients in a synergistic integrated cycle of profit-making processes where the waste of each process becomes the feedstock of another process. The nomenclature of "white biotechnology" is alluded to both industrial and environmental biotechnology. In this respect, biotechnology is well positioned to contribute to the development of sustainable society through a sustainable environment. Gismondi (2000) noted that recombinant DNA technology has improved the possibilities of prevention of pollution and holds a promise for further development of bioremediation. Environmental biotechnology has revolutionized the safety of public health. It provides a systematic platform that submerge the knowledge of science and engineering. By using microorganisms, it prevents pollution by treating and biodegrading the hazardous wastes (Gareth and Judith, 2003).

Daniel (2010) noted that environmental biotechnology has shown to play a significant role in agroecology in the form of zero waste agriculture and most significantly through the operation of over 15 million biogas digesters worldwide. Zero waste agriculture is a type of sustainable agriculture which optimizes use of the five natural kingdoms, that is, plants, animals, bacteria, fungi and algae, to produce biodiverse food, energy and nutrients in a synergistic integrated cycle of profit-making processes where the waste of each process becomes the feed stock for another process. Zero waste agriculture presents a balance of economically, socially and ecologically benefit as it reduces the use of pesticide through biodiverse farming, provide climate change relief through substantial deduction in greenhouse emission from both traditional agricultural practices and fossil fuel usage and many others. It also preserves local indigenous systems and existing agrarian cultural values and practices.

Environmental biotechnology is a system of scientific and engineering knowledge related to the use of microorganisms and other products in the prevention of environmental pollution through biotreatment of solid, liquid and gaseous wastes, bioremediation of polluted environments and biomonitoring of environment and treatment process (Rittman and Carty, 2000). The advantages of biotechnological treatment of waste include; biodegradation or detoxication of a wide spectrum of hazardous substances by natural microorganisms through a wide range of biotechnological methods (bioremediation, biomonitoring, biofiltration etc.) for complete destruction of hazardous waste (Evans and Furlong, 2003).

Biotechnological tools for environmental protection:

Bioremediation

Bioremediation is the use of microorganisms and plants to degrade contaminants in sewage,

domestic, agriculture and industrial effluents into less toxic, non-toxic and useful materials by natural biological processes (Gillespie and Philip, 2013) and may be conducted *in situ* and *ex-situ.* In *in-situ* processes, treatment of contaminated material is done in that place without removal or transportation of sites. *Ex-situ* processes involve the removal of contaminated material to the treatment area (EPA, 2006). The best bioremediation approach (aerobic and anaerobic) largely depends on the type of contaminants and pressure site conditions. Aerobic bioremediation is the most common form of oxidative bioremediation processes where oxygen is provided as an electron acceptor for oxidation of petroleum, polyromatic hydrocarbons (PAHs), phenols and other pollutants. Oxygen is generally the preferred electron acceptor because of the higher energy yield and is also required for some enzyme systems to initiate the degradation process (Vidali, 2001).

Anaerobic bioremediation can be employed to treat a broad range of oxidized contaminants including ethane, chlorinated ethane, chloromethane, chlorinated cyclic hydrocarbons, various energetics (example, pentachlorides) and nitrate (Vidali, 2001). Bioremediation can be an approach used to treat wastes including waste water, industrial waste, solid waste and many others. The aim of bioremediation is the employment of bio-systems such as microbes likes plants (mosses, lichens and many others) and animals to reduce the potential toxicity of chemical contaminants by degrading, transforming and immobilizing these undesirable compounds (Daniel, 2010). It is used to detoxify and restore ecosystems damaged by oil spills. In Ogbogu located in one of the largest oil producing regions of Nigeria, two plant species are utilized to clean up spills. The first stage of cleanup involved *Hibiscus cannabinus*, a plant species indigenous to West Africa, and an annual herbaceous plant originally used for pulp production. This species has high rates of absorbency and can be laid down on top of the water to absorb oil. The oil saturated plant material is then removed and sent to a safe location where the hydrocarbons can be broken down and detoxified by microorganisms. The second stage of bioremediation involves a plant known as *Vetiveria zizanioides*, a perennial grass species. These plant species has a deep fibrous root network that can both tolerate chemicals in the soil and can also detoxify soils through time requiring little maintenance. These methods of bioremediation helped in improving the quality of drinking water, soil conditions, and the health of their surrounding environment (Limson, 2002).

Methods of bioremediation includes: phytoremediation, mycoremediation, landfarming, bioreactor, bioaugumentation, bioleaching, biostimulation, biomarker, biosensoring and biofiltration. Phytoremediation involves the use of plants to control and remove pollutants from soil air and water. Organic and inorganic waste can be removed such as metals, sludge, salts, leachates, metalloids and xenobiotic contaminants can be removed by this method (Eneh and Owo, 2008). Advantages of phytoremediation include low cost and it is environmentally friendly. It may be conducted at scale low installation and maintenance cost, conserving soil structure preventing erosion and leaching (Van, 2009). Phytoremediation can be used in mining operations in order to remove contaminant from polluted sites. Many plants such as mustard plants, alphine, pennycress, hemp and pigweed have been proven to be hyperaccumulating contaminants at toxic waste sites. Thus, the phytoremediation process makes use of specific types of plant and trees that are capable of absorbing contaminant from water. For example, Indian mustard (*Brassica juncea* L.) is used to remove Pb, Se Zn, Hg and Cu. Also, Indian grass (*Sorghastrum nutans*) can detoxify common agro chemical residues such as, pesticides and herbicides (Van, 2009).

Mycoremediation involves the use of fungi to remove chemical contaminants from the soil such as zinc, diesel and chemicals (Eneh and Owo, 2008). In this method the fungus makes use of certain enzymes and acids that it naturally secretes and decompose hazardous chemicals into less and non-toxic compounds.

Land farming is one of the simplest bioremediation approaches owing to its low-cost natural decomposition of hazardous chemicals (Eneh and Owo, 2008). Polluted areas are usually excavated or tilled, and either applied a specialized bacteria or allowing indigenous bacteria to mobilize the contaminants (Besaltatpour *et al*., 2011).

Bioreactor is a vessel that carries out biological reactions in which cultured anaerobic cells degrade waste under controlled and optimal condition (Mohan *et al.,* 2004).

Bioaugmentation is commonly used in municipal wastewater treatment to restart activated sludge bioreactors (Morganwalp, 2015). At sites where soil and ground water are contaminated with chlorinated ethenes, such as, Tetrachloroethylene and Trichloroethylene. Bioaugmentation can be used to ensure that in-situ microorganism of these contaminants are non-toxic in nature (Major *et al*., 2002). Bioleaching is the extraction of metals such as copper, zinc, lead, cobalt and many others from their ores through the use of living organisms like bacteria. It is more environments friendly (Power *et al*., 2010).

Biostimulation involves the modification of the environment to stimulate existing bacteria for greater activity by applying various forms of rare limiting nutrients and electron acceptors such as phosphorus, nitrogen, oxygen or carbon (Kanissery and Sims, 2011). Biomonitoring involves the detection and removal of harmful, toxic, deleterious materials using living organisms (Onwurah *et al*., 2007). This can be achieved with the use of biomarkers (biological makers and biosensors. A biomarker is an organism or part of it, which is used in identifying or detecting the possible harmful effect of pollutant on the environment (Onwurah *et al.,* 2007). For example, chlorophyll production in *Zea mays* may be used to estimate deleterious effect of crude oil contaminants on soil (Ezeonu and Onwurah, 2009). Biosensors on the other hand is an analytical device consisting of a biocatalyst (enzyme, cell or tissue) and a transducer which can convert a biological or biochemical signal or response into a quantifiable signal. They are also often employed for continuous monitoring or detection of harmful substances in water, air, and soil (Ripp *et al*., 2010). They are also used to provide data on what contaminants are present, where they are located and these instruments can be used for wastewater, groundwater, surface water and sediment sample testing (Ripp *et al.,* 2010).

Biofiltration is a pollution control technique employing the use of living organisms to capture and biologically degrade pollutants. Common use of biofiltration processes are for processing waste water, capturing harmful chemicals or silt from surface run-off and metabolic oxidation of contaminants in air. Polluted air flows through a packed bed and the pollutant is transferred into a biofilm on the surface of the packing material where microorganisms including bacteria and fungi are immobilized into biofilm to degrade the pollutant into simple and safer compounds, eventually to carbon dioxide (if aerobic), methane (if anaerobic) and water (Hammes and Juhna 2011)

Its application includes water filtration in farms, livestock operations, city municipal, industrial and household application. Biofiltration is ideal for well, lake, pond, river and canals. Biofilters remove pollutants from air and water, such as iron, bacteria, parasites, colours and dissolved organic material. For example, plants which remove nitrogen from polluted water include *Carex appressa, Melaleuca incana, Juncus kraussir, Carex tereticaulis* and water lilies (John and Simpson 2003).

Biotechnology Products used in the Environmental Protection include biofertilizer, biopesticides, biofuel and bioethanol. A biofertilizer is a substance which contains living organisms which when inoculated or applied to seed, plant surface or soil, colonize the rhizosphere or the interior of the plant and promote growth by increasing the supply or availability of plant nutrients to the host plants. Biofertilizers such as *Rhizobium*, *Azotobacter, Azospirrillium* and blue green algae provide eco-friendly organic input. For example, *Rhizobium* inoculants is used for leguminous crops. Azotobacter can be used with crops like wheat, maize, cotton and many vegetable crops.

Biopesticides are obtained from microorganisms including plants, bacteria, other microbes, fungi, nematodes and many others. Biopesticides are biological or biologically derived agents that are usually applied in a manner similar to chemical pesticides to achieve pest management in an environment friendly way. Biopesticides can be used in seed treatment and soil amendment and they are less toxic to humans and the environment and they do not leave harmful residues, usually specific to target pests (EPA, 2012). The three categories of biopesticies are microbial biopesticides, biochemical biopesticides and plant incorporated protectants (PIPs).

Microbial Biopesticide include bacteria, fungi, oomycetes, virus and protozoa which are all being used for the control of pestiferous insects, plant pathogens and weeds. The most widely used microbial biopesticide is the insect pathogenic bacterium (*Baccillus thuringiensis*). Microbial biopesticide used against plant pathogens include *Trichorderma harzianum* which is a contagonist of *Rhizoctona*, *Phythium* and other soil borne pathogens.

Biochemical Biopesticides are naturally occurring substances that control pests by non-toxic mechanisms, they interfere with mating such as insect sex pheromone, as well as various scented plant extracts that attracts insect's pest to traps. Plants produce a wide variety of secondary metabolites that deter herbivores from feeding on them. The most widely used botanical compound is the neem oil, an insecticidal chemical extracted from seeds of *Azardirachta indica* (Dent, 2020).

Plant Incorporated Protectants (PIPS) are genetically modified organisms which are incorporated into plants (genetically modified crops). Some plants produce insect killing proteins within their tissues because genes from *Bacillus thuringiensis* were inserted into the plant's DNA. Biopesticides have a range of attractive properties that make them good components of IPM. They are also pesticidal substances that plant produce from genetic material that has been added to them. For example, scientists take the gene for the Btpesticidal protein and introduce the gene into the plants genetic material. Then the plant, instead of Bt bacterium, manufactures the substances that destroy the pest. Other products include biofuel, bioethanol and biodiesel.

The Way Forward

Environmental Education and Awareness Programmes should be given priority attention, particularly in the educational curricula to be able to monitor the environmental changes, sources of such changes and their impact on man, plant and animals and utilized sustainable natural resources for the development of humanity and the total development in future (Raimi *et al., 2*019). Unfortunately, Nigerians are poorly aware of their environment and damages being done to it through various activities like deforestation, bush burning, littering/open dumping of human waste, polluting rivers with sewage, oil spillage among others. Environmental education and training programmes related to the remediation of environmental damage with the use of biotechnology should be thought in primary, post primary and higher institutions.

Formal and informal education increase awareness, improve extension services, sensitize people on environmental issues and build institutional capacities. Also, the use of Non formal education should be adopted which benefits the people than formal education. Pollution regulation practices should be implemented to reduce their operational wastes of industries. Clean up campaigns on the highly polluted areas and water bodies should be stepped up. This will help in solving the problem of pollution and environmental damage. Other measures of reducing environmental degradation include the use of Use of Information Communication Technology (ICT), forest regeneration, waste recycling and use of Environmental Impact Assessment (EIA).

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Perceived Effect Of Soot (Hydrocarbon Emission) On The Wellbeing Of People Living In The Niger Delta Region Of Nigeria

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Abstract: The study examined the perceived effect of soot (hydrocarbon emission) on the livelihood and wellbeing of the people living in the coastal plains of the Niger Delta region of Nigeria. Survey design was adopted for the study and one hundred and fifty respondents were used. The data were analyzed using descriptive statistics such as percentage and mean with a bench mark of 1.50. The results show that most Residents perceived that soot prevalence caused psychological effect such as body fatigue, eye irritation and recurrent colds with the highest mean value of 1.99, followed by air hazard with mean value of (X = 1.86). Perceived effect on physical environment such as visible colour, growth on vegetable and water with a mean value of (X=1.76) was also observed. On the perceived effect of soot on wellbeing, *negative effect on* health was ranked the highest with a mean value of (X=1.99) followed by aquatic live at (X=0.72) and livestock with a mean value of (X=1.68) ranked third. The study recommends that there should be adequate awareness creation by government and multinational oil companies on the health and environmental implications of soot. Environmental laws already established on soot emission should also be implemented on defaulters while regional emissions inventory should be provided to constantly monitor sources of soot emission.

Keywords: Soot, hydrocarbon emission, perceived effect, wellbeing of the people

CITATION:
Umoh, E. E., Imikkan, A. M. and Inwang, M. I. (2023). Perceived Effect Perception of Impact of Soot (Hydrocarbon Emission) on the Livelihood and Wellbeing of People Living in the Niger Delta Region of Nigeria. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp.123- 129

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Introduction

The development of technology has led to the exploration of man's environment in a bid to increasing his standard of living. This exploration includes oil drilling which in turn leads to emission of hydrocarbon (soot). Soot emission in the oil-rich Niger Delta Region of Nigeria continues to degrade the environment, affecting human, animal and plant lives; even inanimate objects are affected (Nta *et al*., (2014). Umoh *et al*., (2019) observed that the activities of multinational oil companies in the region has birthed the prevalence of soot affecting both human and animal lives. Nta *et al.,* (2014) also asserted that increase in temperature of the atmosphere, greenhouse effect, acid rain/acidification of aquatic environment, poor agricultural yields and changes in the ecosystem have been mentioned as some of the adverse effects of soot emission. Six major sources of black soot have been identified. burning of local "kpo-fire" crude oil for production of diesel and kerosene 67.5%, smoke from refinery and petro-chemical industries 20%, gas flaring from flow station of oil companies 5%, smoke from

generators both industrial and domestic 3%, smoke from exhaust of vehicles of all types 1.5%, burning of vehicle tyres either at animal slaughter abattoir or for other purposes 3% (Renner and Esther 2016).

Before the discovery of oil in the Niger Delta, the people depended so much on the resources from their natural environment. They made their living from the exploitation of the resources of their land, water and forest as farmers, fishermen and hunters. They were attached to their environment. At that period agricultural growth was related to flourishing rural economy thereby improving the standard of living of the rural farmers. However, soot emissions have constituted great environmental and social problems in the coastal plains of the Niger Delta region of Nigeria; its enormous economic benefits notwithstanding. One of the major problems is the destruction of the people's livelihood which is the soil and farmlands. Soot emissions also affect the soil, vegetation, agriculture and crop production (Alakpodia, 1995, Alakpodia 2000 and Idu et *al*., 2003). The agricultural soils as well as fresh water and aquatic life have been destroyed by various forms of gas generated environmental pollution. Farming has become very difficult and even drinking water has become scarce. Flaring activity affects agricultural production of farmers and other livelihood activities. This results in stunted crop growth and impacts negatively on the yield of crops such as, cassava, yam, plantain, banana and palm trees among others.

Agricultural growth has seriously declined over the past two decades and as a result, affecting the standard of living of the farmers (Umoh *et al* 2019). Global research suggests that particle pollution correlates positively with a range of morbidities and increased risk of mortality among exposed population. This underscores the need for rigorous implementation of existing environmental legislations established to protect the ecosystem, environment and the entire public health (Niger Delta Development Commission - NDDC, 2009).

Agricultural growth has seriously declined over the past two decades and as a result, affecting the wellbeing of the people of the Niger Delta (Etuk *et al*., 2012 and Umoh *et al.,* 2019). Therefore, to improve the wellbeing of these people, there is need to identify the likely indicators that has caused a reduction in agricultural productivity. However, the activities of gas flaring have constituted great environmental and social problems in the region and its enormous economic benefits notwithstanding. One of the agricultural problems is the destruction of the people's livelihood which is the soil, the water and farmlands. Gas flaring affects the soil, vegetation, agriculture and crop production (Etuk *et al*., 2017). The agricultural soils as well as fresh water and aquatic lives have been destroyed by various forms of gas generated environmental pollution. Farming activities and water has become very harsh and scarce. This has resulted in the continuous low yield in crops such as, cassava, yam, plantain, banana and palm trees among others (Etuk *et al.,* 2017). Residents of the coastal region of the Niger Delta are constantly suffering from oil spills suspected to stem from multinational oil companies operating in the area. These impacts are commonly obvious in their environment, human health and total livelihood (Ifeanyi-obi *et al*., 2012 and AgroNigeria, 2016).

The continuous deterioration in air quality in the Niger Delta in recent times has caused a lot of public outcry and anxiety. There is the regularly observed intense carbonized aerosol generally referred to as 'black soot', resulting from a myriad of sources and descending on the city as dry deposition. Ecological damage to plants (crops) through deposition of oxides of carbon, nitrogen, Sulphur and volatile organic compounds in the aerosols on plant leaves, acidification of soils and water bodies will

ultimately lead to poor crop/fruit yields, fish catches, dwindling agricultural productivity and livelihoods and wellbeing (Umoh *et al.,* 2019). As a result of these problems, this study seeks to find out perception of impact of soot (hydrocarbon emission) on the wellbeing of residents of the coastal plains of the Niger Delta region of Nigeria.

Methodology

This study was carried out on the localities along the coastal plains of the Niger Delta in the southern part of Nigeria. The study area stretches from the coastal areas of Akwa Ibom State through Rivers State up to the coastal plains of Bayelsa and Delta states. The population of the study comprised of all the residents in the coastal plains of the Niger Delta region of Nigeria. Three communities were purposively selected in each of Akwa Ibom state, Rivers State and Delta State for the study. These communities were selected because of the prevalence of soot occasioned by the activities of multinational oil companies in the areas. Thereafter, fifty (50) residents were randomly selected from each state making a total of one hundred and fifty (150) respondents in all. Structured questionnaire was used. An in-depth interview method was applied to authenticate the data obtained from the questionnaire. Descriptive statistics such as percent, means and ranking were utilized.

RESULTS AND DISCUSSION

Perception of Residents on the Prevalence of Soot.

The result of the analysis of the perception of residents on the prevalence of soot, of which ranking was measured with a benchmark of 1.50 (below or above the benchmark shows lower or higher perception of the residents on the prevalence of soot respectively) as shown in Table 2. indicates by the ranking of the strength of respondents' perception that, the experience of psychological effects or impacts such as body fatigue, eye irritation, recurrent colds, ranks highest with the mean value of (X = **1.99)** as the strongest perception of the residents in the study area. This is followed by the presence of soot which have constituted hazards of air pollution in the study area with a mean value of (X = **1.86);** followed by observable effects on the physical environment (such as the visible colour and growth of vegetation) with the mean value of (X = **1.76)**; increased soil acidity with a mean value of (X = **1.75)**; amenities left unattended for a few days are often coated with thick soot with a mean value of (X = **1.71)**; higher concentration and suspended particulates (e.g. haze) with a mean value of (X = **1.66)**; atmospheric visibility which is reduced at the mean value of (X = **1.60)**; experience of contamination of soil and water bodies at the mean value of (X = **1.57)**; experience of physical dirt or soot in homes at the mean value of (X = **1.55)**; burning of car tyres which causes soot at the mean value of (X = **1.46)**; and colour and contrast in landscape with the mean value of (X =**1.43)**, all respectively ranked with the mean value accordingly.

However, many toxicological and epidemiological studies such as carried out by (Pope *et al.,* 2002); shows similarities of report with the findings of this research which established that adverse health effects by diesel particulate matter (DPM10, DPM2.5) indicates that exposure of diesel exhaust have been linked with acute short term problems such as irritation of the eyes, nose, and throat vomiting, light-headedness, headache, heartburn, numbness, bronchitis, chronic respiratory, cardiovascular, cardiopulmonary and allergic diseases such as shortness of breath and painful breathing, cancer, and premature death. Some investigations indicate that particles can induce inheritable mutations. The Grand Mean (G.M.) = 1.66 which is above the benchmark, and indicates that there is a higher perception of the residents on the prevalence of soot in the area.

Table 1: Perception of Residents on the Prevalence of Soot.

S/n	Perception of Residents	SA	A	D	SD	Total	Mean	Rank
1	Experience psychological effects or impacts (e.g. fatigue, eye irritation, recurrent colds)	(39) 26.0	(76) 50.7	(32) 21.3	(3) 2.0	**(150) 100**	**1.99**	**1st**
2	Presence of soot have constituted hazards of air pollution	(46) 30.7	(82) 54.7	(19) 12.7	(3) 2.0	**(150) 100**	**1.86**	**2nd**
3	Observable effects on the physical environment (e.g. the colour and growth of vegetation	(100) 66.7	(40) 26.7	(6) 4.0	(4) 2.7	**(150) 100**	**1.76**	**3rd**
4	Increased soil acidity	(46) 30.7	(97) 64.7	(6) 4.0	(1) 0.7	**(150) 100**	**1.75**	**4th**
5	Amenities left unattended for a few days are often coated with thick soot	(61) 40.7	(73) 48.7	(15) 10.0	(1) 0.7	**(150) 100**	**1.71**	**5th**
6	Higher concentration and suspended particulates (e.g., haze)	(61) 40.7	(80) 53.3	(8) 5.3	(1) 0.7	**(150) 100**	**1.66**	**6th**
7	Atmospheric visibility is reduced	(65) 43.3	(80) 53.3	(3) 2.0	(2) 1.4	**(150) 100**	**1.60**	**7th**
8	Experience of contamination of soil and water bodies	(73) 48.7	(69) 46.0	(5) 3.3	(3) 2.0	**(150) 100**	**1.57**	**8th**
9	Experience of physical dirt or soot in home	(75) 50.0	(59) 39.4	(8) 5.3	(8) 5.3	**(150) 100**	**1.55**	**9th**
10	Burning of car tires causes soot	(92) 61.3	(47) 31.3	(10) 6.8	(1) 0.7	**(150) 100**	**1.46**	**10th**
11	Colour and contrast in landscape	(90) 60.0	(50) 33.4	(5) 3.3	(5) 3.3	**(150) 100**	**1.43**	**11th**

Source: Field Survey, 2012 , G.M. = 1.66 (Benchmark = 1.50)
Where: SD = Strongly Agree, A = Agree, D = Disagree, SD = Strongly Disagree

Perceived effects of Soot on the Wellbeing of Residents

The result of the analysis on the effects of soot on wellbeing of residents in terms of housing, health, sanitation, nutrition, education and livelihood as shown in Table 3, with a benchmark of 1.50 (below or above the benchmark shows lower or higher effects of soot on wellbeing of the residents respectively), indicates by a ranking of the strength or the seriousness of the effect of soot on the wellbeing of residents according to their mean value, that human health with a mean value of (X= 1.99) ranks highest an aspect of the residents' wellbeing which is affected by soot; followed by fish population at a mean value of (X = 1.73); marine at a mean value of (X =

1.72); livestock at a mean value of (X = 1.68); soil productivity at the mean value of (X= 1.66); livelihood activities with a mean value of (X = 1.63); weather, with the mean value of (X= 1.59); water/rain, with the mean value (X= 1.58); and infrastructures, with a mean value of (X= 1.35) as the least aspect of the wellbeing of residents in the study area affected by soot.

However, the findings of this research coincide with the assertion of (Yakubu 2017); who identified that soot emissions contribute to the development of health problems; pollution of air, water, and soil; soiling of buildings; reductions in visibility; impact agriculture productivity, global climate change, etc. He further, asserted that special attention is given to the smaller fractions of PM (PM 2.5 and PM 0.1) because these particles can penetrate deep into the bronchiolar parts of the lungs and cause various health hazards. The grand mean (G.M.) = 1.66. This shows that there is a higher effect(s) of soot on the wellbeing of residents in the area in terms of housing, health, sanitation, nutrition, education, and livelihood.

Table 2: Perceived Effect of Soot on the Wellbeing of Residents

S/n	Effects	VS	S	MS	NS	Total	Mean	Rank
1	Negative effect on Human health	52 (34.7)	54 (36.0)	38 (25.3)	6 (4.0)	**150 (100)**	**1.99**	**1st**
2	Negative effect on Fish population	63 (42.0)	66 (44.0)	19 (12.7)	2 (1.3)	**150 (100)**	**1.73**	**2nd**
3	Negative effect on Marine animals	67 (44.7)	58 (38.7)	21 (14.0)	4 (2.6)	**150 (100)**	**1.72**	**3rd**
4	Negative effect on Livestock	62 (41.3)	74 (49.3)	10 (6.8)	4 (2.6)	**150 (100)**	**1.68**	**4th**
5	Negative effect on Soil productivity	74 (49.3)	54 (36.0)	21 (14.0)	1 (0.7)	**150 (100)**	**1.66**	**5th**
6	Negative effect on Livelihood activities	75 (50.0)	57 (38.0)	16 (10.7)	2 (1.3)	**150 (100)**	**1.63**	**6th**
7	Negative effect on Weather	79 (52.7)	53 (35.3)	10 (6.8)	8 (5.2)	**150 (100)**	**1.59**	**7th**
8	Water/rain	80 (53.3)	53 (35.3)	10 (6.8)	7 (4.5)	**150 (100)**	**1.58**	**8th**
9	Infrastructures	104 (69.3)	40 (26.7)	4 (2.7)	2 (1.3)	**150 (100)**	**1.35**	**9th**

Source: Field Survey, 2012 G.M. = 1.66
(Benchmark = 1.50)
Note: The figures in parenthesis are in percentages.
Where VS = Very Seriously, S = Seriously, MS = Moderately Serious, NS = Not Seriously

Conclusion

From the results obtained, it can be concluded that the perceived effect of soot emissions on the wellbeing of residents of the coastal planes of the Niger Delta has negative effects on health which ranks the highest, followed by fish population and aquatic life. Other negative effects include livestock, soil productivity, potable water and general livelihood. The present air pollution situation in the areas calls for positive urgent action on the part of government, academia, civil society, corporate organizations, all and sundry. They are all being slowly poisoned, and the consequences will certainly manifest in forms and magnitudes that we have not yet contemplated, far into the

future. A continuation of the present levels of air pollution within the city and other parts of these states is a sure recipe for a rapid deterioration in not only the quality of life, but also can lead to a serious compromise in the aesthetics of our surroundings and amenities. As much as the Nigeria oil industry has affected the country positively, by fashioning a remarkable economic landscape and contributing to foreign exchange, earning, it also has a negative impact on the socio-economic life and the environment of the host communities and its inhabitants. We should all rise as one to 'Stop this Soot' and demand cleaner and safe air.

Recommendations

Based on the findings and conclusion, the following recommendations are made

1. Creation of awareness by government and multinational oil companies on the health and environmental implications of soot on residents.
2. The Environmental Law Enforcement Agencies, especially DPR (Department of Petroleum Resources), should be more involved in enforcing all existing environmental laws on soot emissions so as to ensure the well-being of the community and Regional Emissions Inventory should also be provided to constantly monitor the sources, volumes and duration of all emissions within the State/Region as a primary step in air quality management.

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Impacts Of Human Population Growth On The Aquatic Ecosystems: A Global View

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***Abstract**: Growth of human population is a major factor affecting the aquatic environments. As human population continues to expand, prosperity and the quality of life can be expected to decline because resources must be shared among more people. Natural resources in our ecosystems such as seas do not expand, this implies that the bigger the population, the greater the impact on our aquatic ecosystems which subjects it to great danger. The current world population is 7.7 billion according to the most recent United Nations estimate. Population in the world is currently growing at a rate of 1.09% per year down from 1.12% in 2017 and 1.14% in 2016. The current increase is estimated at 83 million people per year. An aquatic ecosystem is composed of biotic communities that are structured by biological interactions and abiotic environmental factors. The activities of the increased humans that negatively affect the aquatic ecosystems include: agriculture, oil pollution, overfishing, gas flaring, eutrophication, plastic pollution (mechanical and ingestion), acid rain, urbanization, global warming, poor water management, use of pesticides and herbicides. These activities endanger the aquatic biota such as algae, worms, crustaceans, protozoans, birds, fish and mammals. In other words, both the producers (green plants), consumers (animals) and decomposers (bacteria and fungi) are adversely affected. Generally, aquatic productivity has been impaired by increased human population. This review also highlights the proffered solutions to harness this menace.*

***Key words:** Human population growth, aquatic ecosystem, impacts, natural resources, pollution*

CITATION:
Ekpo, I. E. and Essien-Ibok, M. A. (2023). Impacts of Human Population Growth on the Aquatic Ecosystems: A Global View. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 101- 122

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Introduction

Throughout human existence, aquatic ecosystems have been relied on for many things: food, recreation, medicine, economic opportunities, transportation, among many others. They provide a wide array of essential and economically valuable services, including use for agricultural, industrial and municipal purposes, transportation corridors, food, opportunities for recreation and esthetic enjoyment and waste disposal (Petts, 1989). They play a significant role both as the world's largest habitat and climate regulator. Water resources are typically needed for the sustenance of life, growth and development. Water serves as habitat to several biodiversity especially fishes (shell and finfish), aquatic reptiles, mammals, birds and breeding ground for several other diversity such as frogs, parasites of medical importance such as Schistome and vectors transmitting diseases such as mosquitoes. As such, water is a unique place for life to thrive. Water is also used for

domestic purposes such as washing, cooking and bathing. Most water resources are from surface, ground and rain waters (Izah and Srivastav, 2009). Izah *et al.*, (2016) opined that groundwater is mostly consumed in the Niger Delta and that surface water and rainwater also serve as potable water sources in regions that groundwater/borehole water is unavailable. However, the world's aquatic ecosystems have suffered a lot at the hands of humans and population growth has increasingly compounded the problem by pushing them to their limits and altering them beyond their natural state (World Population Prospects, 2017).

The current world population is 7.7 billion according to the most recent United Nations estimate. Population in the world is currently growing at a rate of 1.09% per year down from 1.12% in 2017 and 1.14% in 2016. The current increase is estimated at 83 million people per year (World Population Prospects, 2017). Aquatic ecosystems are being affected by oil pollution, eutrophication, acid rain, climate change, gas flaring, overfishing, and so on, some of which are the results of human activities such as urbanization, industrialization, indiscriminate use of pesticides and fertilizers in agriculture, petroleum exploration, exploitation and refining as well as transportation, storage, marketing and use of petroleum products (Oribhabor, 2016; Ekpo *et al*., 2018). This paper, therefore presents information on aquatic ecosystems, the growth of human population, how this growth has intensified the adverse impacts of human activities on aquatic ecosystems and recommendations proffered.

Aquatic Ecosystems

Communities of organisms that are dependent on each other and on their environment live in aquatic ecosystems. The two main types of aquatic ecosystems are marine ecosystems and freshwater ecosystems (Alexander, 1999).

Types of Aquatic Ecosystems

Marine Ecosystems

Marine ecosystems cover approximately 71% of the Earth's surface and contain approximately 97% of the planet's water (Nathan *et al*., 2021). They generate 32% of the world's net primary production (Silliman *et al*., 2009). They are distinguished from freshwater ecosystems by the presence of dissolved compounds, especially salts, in the water. Approximately 85% of the dissolved materials in seawater are sodium and chlorine. Seawater has an average salinity of 35‰ of water and varies among different marine ecosystems (Alexander, 1999).

Classification of marine habitats

Marine ecosystems can be divided into many zones depending on water depth and shoreline features. The oceanic zone is the vast open part of the ocean where animals such as whales, sharks, and tuna live. The benthic zone consists of substrates below water where many invertebrates live. The intertidal zone is the area between high and low tides. Other near-shore (neritic) zones can include estuaries, salt marshes, coral reefs, lagoons and mangrove swamps. In the deep water, hydrothermal vents may occur where chemosynthetic sulfur bacteria form the base of the food web.

Classes of organisms found in marine ecosystems include brown algae, dinoflagellates, corals, cephalopods, echinoderms and sharks. Fishes caught in marine ecosystems are the biggest source of commercial foods obtained from wild populations (Silliman *et al*., 2009). Furthermore, environmental problems concerning marine ecosystems include unsustainable exploitation of marine resources (overfishing of certain species), marine pollution, climate change and building on coastal areas.

Freshwater Ecosystems

Freshwater ecosystems cover 0.78% of the Earth's surface and inhabit 0.009% of its total water. They generate nearly 3% of its net primary production. Freshwater ecosystems

contain 41% of the world's known fish species (United States Environmental Protection Agency, 2006).

Functions of Aquatic Ecosystems

Aquatic ecosystems perform many important environmental functions. They recycle nutrients, purify water, attenuate floods, recharge ground water and provide habitats for wildlife (Gasteseu, 1993). They are also used for human recreation, and are very important to the tourism industry, especially in coastal regions (USEPA, 2006). The health of an aquatic ecosystem is degraded when the ecosystem's ability to absorb a stress has been exceeded. A stress on an aquatic ecosystem can be a result of physical, chemical or biological alterations of the environment. Physical alterations include changes in water temperature, water flow and light availability. Chemical alterations include changes in the loading rates of bio-stimulatory nutrients, oxygen consuming materials, and toxins. Biological alterations include over-harvesting of commercial species and the introduction of exotic species. Human populations can impose excessive stresses on aquatic ecosystems (Gasteseu, 1993). Excessive stresses with negative consequences illustrate how multiple stresses, such as water pollution, over-harvesting and invasive species can combine (Loeb, 1994), including levee construction, logging of swamps, invasive species and salt water intrusion (Moss, 1983).

Abiotic characteristics of Aquatic Ecosystems

Some of the important abiotic environmental factors of aquatic ecosystems include substrate type, water depth, nutrient levels, temperature, salinity and flow (Alexander, 1999; Vaccari, 2005). There may be complicated feedback loops: sediment may determine the presence of aquatic plants, but aquatic plants may also trap sediment, and add to the sediment through peat. The amount of dissolved oxygen in a water body is frequently the key substance in determining the extent and kinds of organic life in the water body. Fish need dissolved oxygen to survive, although their tolerance to low oxygen varies among species; in extreme cases of low oxygen some fish even resort to air gulping (Keddy *et al.*, 2007). Conversely, oxygen is fatal to many kinds of anaerobic bacteria (Sculthorpe, 1967). The relative abundance of nitrogen and phosphorus can in effect determine which species of algae come to dominate (Smith, 1983). Algae are a very important source of food for aquatic life, but at the same time, if they become over-abundant, they can cause declines in fish when they decay (Loeb, 1994). Similar over-abundance of algae in coastal environments produces, when decay, a hypoxic region of water known as a dead zone (Turner and Rabelais, 2003).

The salinity of the water body is also a determining factor in the kinds of species found in the water body. Organisms in marine ecosystems tolerate salinity, while many freshwater organisms are intolerant of salt. The degree of salinity in an estuary or delta is an important control upon the type of wetland, and the associated animal species. Dams built upstream may reduce spring flooding, and reduce sediment accretion, and may therefore lead to saltwater intrusion in coastal wetlands (Clegg, 2007). Freshwater used for irrigation purposes often absorbs levels of salt that are harmful to the organisms (Sculthorpe, 1967).

Biotic characteristics of Aquatic Ecosystem

Biotic characteristics are mainly determined by the organisms that occur. Wetland plants may produce dense canopies that cover large areas of sediment, or snails, insects, worms and geese may graze the vegetation leaving large mud flats. Aquatic environments have relatively low oxygen levels, forcing adaptation by the organisms found there. Many wetland plants must produce parenchyma to carry oxygen to roots. Other biotic characteristics are more subtle and difficult to measure, such as the relative importance of competition, mutualism

or predation (Clegg, 2007). There are a growing number of cases where predation by coastal herbivores including snails, geese and mammals appear to be a dominant biotic factor (Silliman *et al.*, 2009).

Autotrophic organisms are producers that generate organic compounds from inorganic material. Algae use solar energy to generate biomass from carbon dioxide and are possibly the most important autotrophic organisms in aquatic environments (Sculthorpe, 1967). The more shallow the water, the greater the biomass contribution from rooted and floating vascular plants. These two sources combine to produce the extraordinary production of estuaries and wetlands, which autotrophic biomass is converted into fish, birds, amphibians and other aquatic species.

Chemosynthetic bacteria are found in benthic marine ecosystems. These organisms are able to feed on hydrogen sulfide in water that comes from volcanic vents, which possess great concentrations of animals that feed on these bacteria. Examples are giant tube worms, (*Riftia pachyptila*) 1.5m in length and clams, (*Calyptogena magnifica*) 30cm long (Chapman and Reiss, 1998). Heterotrophic organisms consume autotrophic organisms and use the organic compounds in their bodies as energy sources and raw materials to create their own biomass (Sculthorpe, 1967). Euryhaline organisms are salt tolerant and can survive in marine ecosystems, while stenohaline or salt intolerant species can only live in freshwater environments (Alexander, 1999).

World Population: Past, Present and Future

At the dawn of agriculture, about 8000 B.C., the population of the world was approximately 5 million and over the 8,000-year period up to 1 A.D., it grew to 200 million, with a growth rate of under 0.05% per year (World Population Prospects, 2017). A tremendous change occurred with the industrial revolution: whereas it had taken all of human history until around 1800 for world population to reach one billion, the second billion was achieved in only 130 years (1930), the third billion in 30 years (1960), the fourth billion in 15 years (1974), and the fifth billion in only 13 years (1987) (World Population Prospects, 2017). During the 20th century alone, the population in the world has grown from 1.65 billion to 6 billion. In 1970, there were roughly half as many people in the world as there are now. Because of declining growth rates, it will now take over 200 years to double again (World Population Prospects, 2017).

Yearly Population Growth Rate

Worldometers (2018) revealed that the population in the world is currently growing at a rate of around 1.09% per year (Table 1). The current average population increase is estimated at 83 million people per year (World Population Prospects, 2017). Annual growth rate reached its peak in the late 1960s, when it was at around 2%. The rate of increase has nearly halved since then, and will continue to decline in the coming years. It is estimated to reach 1% by 2023, less than 0.5% by 2052, and 0.25% in 2076 (a yearly addition of 27 million people to a population of 10.7 billion). In 2100, it should be only 0.09%, or an addition of only 10 million people to a total population of 11.2 billion (World Population Prospects, 2017). World population will therefore continue to grow in the 21st century, but at a much slower rate compared to the recent past. World population has doubled (100% increase) in 40 years from 1959 (3 billion) to 1999 (6 billion).

It is now estimated that it will take another nearly 40 years to increase by another 50% to become 9 billion by 2037 (Table 2). The latest world population projections indicate that world population will reach 10 billion persons in the year 2055 and 11 billion in the year 2088 (World Population Prospects, 2017).

Impacts of Human Population on the Aquatic Ecosystems

Human impacts on the aquatic ecosystems have increased along with our rapid population growth, substantial developments in technology, and significant changes in land use and so on. Almost everything produced by man or resulting from human activities can bring about contamination and eventual pollution of aquatic ecosystems and as human population grows, the effects of their activities on water bodies also increase (Don-Pedro, 1990). Human activities such as deforestation, channelization, filling and construction of canals, levees, dams, roads and bridges, agricultural, industrial and domestic activities, introduction of exotic species, over-exploitation of plant and animal species upset the hydrological regime, sediment characteristics and several biotic components. Upstream activities bring pollutants into mangrove swamps and estuaries (Oribhabor, 2016). Basically, it can be said that the activities of man affect the aquatic ecosystems and as the human population grows, the impacts of these activities on the water bodies intensify and increase.

Table 1: World Population Historical Table

Year	Population	Yearly % Change	Yearly Change	Median Age	Fertility Rate	Density (P/Km²)	Urban Pop %	Urban Population
2018	7,632,819,325	1.09	82,557,224	29.9	2.51	51	54.9	4,186,975,665
2017	7,550,262,101	1.12	83,297,821	29.9	2.51	51	54.4	4,110,778,369
2016	7,466,964,280	1.14	83,955,460	29.9	2.51	50	54.0	4,034,193,153
2015	7,383,008,820	1.19	84,967,932	30	2.52	50	53.6	3,957,285,013
2010	6,958,169,159	1.24	83,201,955	29	2.57	47	51.3	3,571,272,167
2005	6,542,159,383	1.26	79,430,479	27	2.63	44	48.9	3,199,013,076
2000	6,145,006,989	1.33	78,706,515	26	2.75	41	46.5	2,856,131,072
1995	5,751,474,416	1.53	84,106,191	25	3.02	39	44.7	2,568,062,984
1990	5,330,943,460	1.81	91,432,333	24	3.44	36	42.9	2,285,030,904
1985	4,873,781,796	1.80	83,074,052	23	3.60	33	41.1	2,003,049,795
1980	4,458,411,534	1.79	75,864,867	23	3.87	30	39.2	1,749,539,272
1975	4,079,087,198	1.97	75,701,910	22	4.46	27	37.6	1,534,721,238
1970	3,700,577,650	2.07	72,196,992	22	4.92	25	36.5	1,350,280,789
1965	3,339,592,688	1.94	61,276,032	23	4.96	22	N.A.	N.A.
1960	3,033,212,527	1.82	52,193,998	23	4.89	20	33.6	1,019,494,911
1955	2,772,242,535	1.80	47,193,563	23	4.96	19	N.A.	N.A.

Source: Worldometers (2018)

Table 2: World Population Forecast (2020-2050)

Year	Population	Yearly % Change	Yearly Change	Median Age	Fertility Rate	Density (P/Km²)	Urban Pop. %	Urban Population
2020	7,795,482,309	1.09	82,494,698	31	2.47	52	55.6	4,338,014,924
2025	8,185,613,757	0.98	78,026,290	32	2.43	55	57.5	4,705,773,576
2030	8,551,198,644	0.88	73,116,977	33	2.39	57	59.2	5,058,158,460
2035	8,892,701,940	0.79	68,300,659	34	2.35	60	60.7	5,394,234,712
2040	9,210,337,004	0.70	63,527,013	35	2.31	62	62.1	5,715,413,029
2045	9,504,209,572	0.63	58,774,514	35	2.27	64	63.5	6,030,924,065
2050	9,771,822,753	0.56	53,522,636	36	2.24	66	64.9	6,338,611,492

Source: Worldometers , 2018

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Agricultural Activities

Surface and ground water contamination in an agricultural land is mainly attributed to outdated farm management practices such as excessive use of fertilizers for high product yields, traditional irrigation practices, use of pesticides and herbicides, poorly managed animal farming operations (Moss, 2008); other sources include fracking, deforestation, atmospheric deposits by rainfall and untreated sewage waste. These practices may result in nutrient, chemical, pathogen and sediment fluxes with main nutrient issues being due to excess phosphorous and nitrogen losses (USEPA, 2009).

Fertilizers rich in phosphorous, potassium and nitrogen are added to soil to increase crop yields. However, agronomic nutrient recommendations are often far in excess of environmental levels (Mueller *et al.*, 1996). Therefore, application of nutrients contained in manures and artificial fertilizers often remain in the soil or are leached into the drainage (Vanlauwe *et al.*, 2001). Enrichment of water because of nutrients (eutrophication) (Nixon, 1995), can give rise to toxic algal blooms which contaminates drinking water and harms aquatic life (Smith and Schindler, 2009). This acknowledges the need for a mechanism to monitor and assess nutrient inputs to crops, its uptake by crops and losses through runoffs and leaching from farms.

Poor water management

Irrigation techniques such as surface flooding, localized drip and subsurface irrigation might be efficient in some ways but they can lead to various problems. Under-irrigation, drip irrigation can lead to salt buildup on the soil surface and can damage crops. Over-irrigation in surface irrigation, may not only trigger nutrient/chemical runoff, but can also cause perched water tables resulting in soil salinity problems (Mckergow *et al.*, 2003). Furthermore, due to scarce water resources, low quality water is being increasingly used for irrigation which is rich in nutrients and salts (Pereira *et al.*, 2002). This increases the risk of salt accumulation in the root zone and consequent long-term damage to crop production and soil fertility (Pitman and Lauchli, 2004; Tedeschi and Dell'aquila, 2005).

Inadequately managed animal farming operations

Manure run-off due to rainfall or poorly managed animal farming operations may carry pathogens like bacteria and viruses to water bodies, thus, affecting water quality for both aquatic life and humans (Lipp *et al.*, 2001; Ferguson *et al.,* 2003). In order to maintain and improve animal health within animal feeding operations facilities and to prevent any pathogen and chemical fluxes through fecal discharges from them.

Use of Pesticides and Herbicides

Pesticide and herbicide applications on crops contribute to chemical deposits in soil, which are carried through runoff and leaching into rivers, lakes and groundwater (Guzzella *et al.*, 2006). Antibiotics are fed to livestock as growth enhancers, and manure containing these pharmaceuticals is spread on land, from where it leaches into ground water and reservoirs (Daughton, 2004).

Oil Pollution

As human population increases, so does the demand for oil. Oil is the primary source driver for the world Organization for Economic Co-operation and Development (OECD) and non-OECD nations (Fig. 1). Thousands of every day products, from medicines to plastics and fibers to clothing from crude. It produces gasoline, diesel and fuel. Oil literally drives the economies of the world. It touches almost every aspect of life. Moreover, there are no affordable substitutes for most of the products gotten from oil. Crude oil is the largest segment of the global oil and gas market, accounting for 64.1% of the market's total value (Prasad and Prasad, 2000).

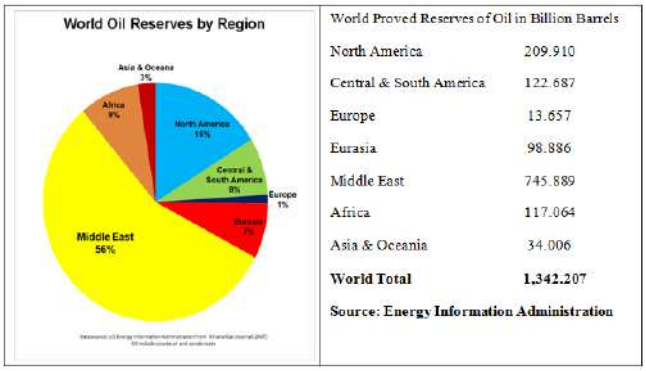

Fig. 1: World Oil Reserves by Region (Source: Energy Information Administration, 2016)

Pollution Due to Oil Spills in Marine Environment

Energy consumption is a primary source of pollution and energy production is a primary source of environment destruction (Table 3). Oil and gas industry is one of largest money earning industry. At the same time, it is the dirtiest and environment-destructive industry on the planet earth. There are more than 40,000 oil and gas fields of all sizes in the world (United Nations, 2004). There are tremendous technological advancements in oil industry from prospecting at great oceanic depths to distribution to customer in retail petrol bunks. But oil is the commonest pollutant in the oceans and more than 3 million metric tons of oil contaminate the sea every year (Prasad and Prasad, 2000). From 1940s green point oil spill to recent deep water horizon oil spill at sea water pollutes the marine environment. An oil spill is unintentional release of liquid petroleum hydrocarbons in to the environment due to human activity or natural disaster (Prasad and Prasad, 2000).

Table 3: Major sources of oil spill to the marine environment

S/N	Factor	% Contribution
1.	Industrial waste reach the sea	37
2.	Oil vessels during transportation	33
3.	Accidents involving tankers	12
4.	During exploration operations	2
5.	Natural sources like fissures from sea bed	7
6.	Absorbed from atmosphere	9

Source: Australian Institute of Petroleum, (2016)

Causes of Oil Spills at Off-Shore

i.) Rig Fires: These are usually associated with unexpected blowouts of liquid and gaseous hydrocarbons from the well as a result of encountering zones with abnormally high pressure. These types of spills are considerable, primarily due to their regularity leading, ultimately, to chronic impacts on the marine environment.

ii.)Crude oil and Petroleum Products Transportation: Crude oil seaborne shipments are increasing 1.1% per year. World shipments of petroleum products are increased by 2.7%, estimate to reach 915.3 million tons. Developed regions accounted for 41.0% of world petroleum products loaded, and 56.1% of world petroleum products unloaded. Daily 40 to 45 million barrels of oil is transported by tankers and most of the oil spills occurred crude oil transportation.

Generally, oil spill occurs if the equipment breaks down or fails, the tanker may get stuck on shallow sediment. When it starts to drive again, there can put a hole in the tanker causing it to leak oil into the sea. The spill happens when

tanker collide with other ships or tankers, aground on reef, exploded due to fire, lightering accidents, hull damage and bilge pumping from ships (Ekpo *et al*., 2018). Sometimes the tankers or vessels hit the off-shore installations. Disasters like hurricanes may cause an oil spill, too.

iii.) Storage: Under water storage tanks for hydrocarbons are necessary elements of many off-shore oil and gas fields. They are built near the platform foundations or anchored in semi-submerged position in the sea area. Sometimes anchored tankers are used for this purpose as well. Risk exists of damaging the underwater storage tanks, especially during tanker loading operations or under severe weather conditions.

iv.) Pipelines: Complex and extensive systems of underwater pipelines have a total length of thousands of kilometers. They carry oil, gas, condensate, and their mixtures from off-shore installations to onshore terminals and processed crude from onshore refineries to off-shore storage tanks (SPM). These pipelines are among the main factors of environmental risk during offshore oil developments, along with tanker transportation and drilling operation. They range from material defects, poor welding and joints and pipe corrosion due to ground erosion, and encountering ship anchors and bottom trawls. The other factors for oil spills are war between countries, illegal dumping of waste oil by industries and terrorist activities (Prasad and Prasad, 2000).

Oil Spill Behavior

When oil is spilled in the ocean, it initially spreads in the water (primarily on the surface), depending on its relative density and composition (Longwell, 2002). The oil slick formed may remain cohesive, or may break up in the case of rough seas. Waves, water currents, high temperature and wind force the oil slick to drift over large areas. Only ten minutes after a spill of 1 ton of oil, the oil can disperse over a radius of 50m, forming a slick 10-mm thick. The slick gets thinner as oil continues to spread, covering an area of up to 12km^2 (Longwell, 2002).

Impacts of Oil on Marine Environment

There is no clear relationship between the amount of oil spilled in the marine environment and the likely impact on wildlife (Ekpo *et al*., 2018). A smaller spill at the wrong time/season and in a sensitive environment may prove much more harmful effect than a larger spill at another time of the year in another or even the same environment. Even small spills can have very large effects (Longwell, 2002). Every situation is unique and depending on the particular conditions and circumstances in that area, and on the characteristics of the spill, some areas might recover in a matter of weeks, others will need up to 20 years (Longwell, 2002).

The oil may enter the killer whales blowhole. A blowhole is a hole to help them breath. Whales will rise up over the water to take a breath. If the blowhole is plugged with oil slick, the whale cannot breath. The main reason for whales dying because of a spill happens when they eat fish that swam through the oil, the whale will eat the oil along with the fish (Nicholas, 2011). Spill damage in shallow waters is most often caused by oil becoming mixed into the sea by wave action or by dispersant chemicals used inappropriately. In many circumstances, the dilution capacity is sufficient to keep oil concentrations in the water below harmful levels, but in cases where light, toxic products have become dispersed, or in major incidents where heavy wave action has dispersed large volumes of oil close inshore, large mortalities of marine organisms such as shellfish and corals (Nicholas, 2011).

When spill occurs near the shoreline, the ecological damage is great. Coastal areas are home to more concentrated and diverse populations of marine life than at sea. Spills can also severely harm turtle eggs and fish larva, causing deformities. Oil spills are also responsible for tainting algae, which perform a

vital role in waterway ecosystems. If a spill is not contained quickly, oil can lie beneath the surface of beaches and the sea, severely affecting marine organisms that burrow, such as crabs, for decades. Since these burrowing creatures are a food source for other aquatic animals, the cycle of poisoning can continue for many years (Yoshioka and Carpenter, 2015). In tropical regions, mangrove swamps replace salt marshes and provide an extremely rich and diverse habitat as well as coastal protection and important spawning, nursery and feeding areas. Damage is more likely if oil smothers their breathing roots or if toxic oils penetrate the sediments. Where high mortality of trees occurs, in some cases including trees which are 50 or more years old, natural recovery to a diverse and productive structure can take decades (Nicholas, 2011).

Other Impacts Due to Oil Spill

Economic loss: A common cause of economic loss to fishermen is interruption to their activities by the presence of oil or the performance of clean-up operations. Sometimes, this results from a precautionary ban on the catching and sale of fish and shellfish from the area, hazard to man's health through eating contaminated sea foods and products, reduced recreational activities, and decrease in aesthetic values due to unsightly slicks or oiled beaches (Nicholas, 2011).

Overfishing: Humans living near the coast have probably always used the water bodies as a source of food. However, with advances in fishing equipment, larger ships and new tracking technologies, many fish stocks around the world have reduced significantly. Fish stocks on continental shelf areas are now widely considered to be fully or over-exploited. Unsustainable fishing practices can have other negative impacts on the marine environment: some fishing techniques such as dredging and trawling can cause widespread damage to marine and organisms living on the sea floor and often capture non-target that are then discarded (Scales, 2007; Bolster, 2012).

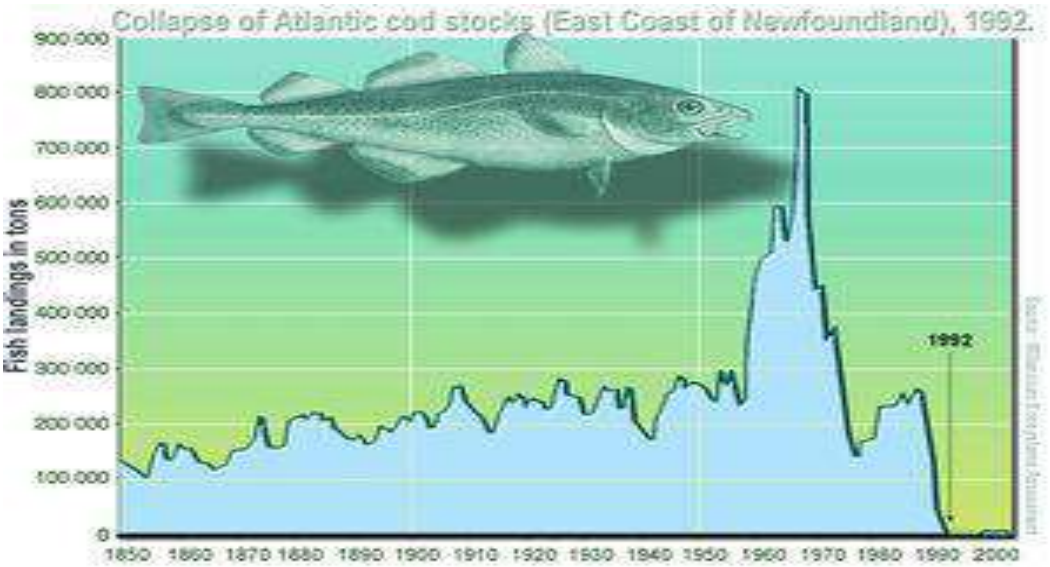

Fig. 2: Collapse of Atlantic cod stock

Gas Flaring

Global estimate indicates that the flaring of petroleum-dissociated gas in the coastal area of Nigeria alone account for 28% of total gas flared in the world (Ekpo *et al*., 2018). Nigeria, like every coastal country has a coastal based economy through the onshore and offshore oil exploration and hence majority of industries and commerce are located along the area in

proximity with ports and borders for effective transit of goods and services (Ismal and Umukoro, 2012). These factors put so much pressure on the coastal biodiversity and reduce their suitability. Globally, high amount of gas is flared into the environment by oil and gas producing countries. Nigeria being among the world producing nations, flare a significant number of natural gases into the environment through vertical and horizontal flaring stack.

Globally, about 110 billion cubic meters of associated gas is flared per annum (Ismal and Umukoro, 2012). Ogbe (2010) opined that Nigeria accounts for about 12.5% global flared gases per annum. Flaring of gases is a global issue for some decades now and Emam (2015) described gas flaring as the use of combustion device (flare stack) to remove unwanted gases and liquids during operation in many industrial processes, such as; oil-gas extraction, refineries, chemical plants, coal industry and landfills to prevent unplanned over-pressuring. Gas is flared in producing nations due to a number of reasons such as inadequate infrastructure to collect, treat, transport and utilize the associated gases; location of the production site is remote from the market demand (such as offshore sites); small volume of the gas and its fluctuation, which make the design of facilities more uncertain and therefore uneconomical investment; impurities in the gas that require hard and expensive treatment methods (such as highly acidic gases); safety and operational reasons (Ogbe, 2010). Gas flaring leads to release of three major components including noxious gases, heat and noise. Natural gas can be converted into different forms for downstream applications including electricity generation and cooking gas. But due to inadequate resources for its conversion and utilization, oil and gas companies prefer to flare the gases and pay compensation. According to (Donwa *et al*., 2015), wastage of gases through flaring is carried out due to problems associated to processing, storing and transporting it in Nigerian setting (Emam, 2015) . Nigeria flare significant amount of natural gas into the environment leading to loss of substantial amount of money per annum. For instance, World Bank reported that 150 to 170 billion m^3 of gases are flared annually, worth up to about $30.6 billion, the price equivalent of one-quarter of the United States' gas consumption or 30% of the European Union's yearly gas consumption (Emam, 2015). Lower amount of gas equivalent have been reported to loss due to gas flaring to the tone of $2.0 billion per annum (Ogbe, 2010). Despite the incentives to capture the associated gas and bring it to market, the volume of gas flared is still high (Donwa *et al*., 2015).

Furthermore, Nigeria flares about 11–42.54% of total natural gas produced, this make Nigeria one of the largest gas flaring nations in the World (Ogbe, 2010). About 17 billion m^3 of associated gas are flared leading to the releasing 2,700, 160, 5400, 12 million and 3.5 million tons of particulate, sulphur oxides, carbon monoxide, carbon dioxide and methane respectively (Oniemola and Sanusi, 2009). The number of wells has far increased due to continual exploration.

Impacts of Gas Flaring on Water Quality and Vegetation Resources

Gas flaring typically has two valves: high and low gas pressure valves. Hence, the concentration of emissions and noise released is a function of the valve used in flaring the gas as well as the physical composition of the gas prior to flaring. The flared gases affect several environmental components as well as its biotic compositions in the following ways:

1.) Changes in Water Quality

Water is typically impacted by gas flaring activities in many coastal regions of the world. Some water quality parameters of surface water, ground water and rain water are affected in gas flaring locations in the Niger Delta (Izah *et al*., 2016). Dami *et al.*, (2012) reported on the impacts of gas flaring and oil spillage on

rainwater quality for domestic use in Okpai and Beneku areas of Delta State observed that temperature, taste, colour, conductivity, total dissolved salts and alkalinity were altered when compared to permissible limits specified by national and international quality standards for drinking water. Others: gas flaring area contain higher concentrations of metals such as barium, cyanide, selenium, cadmium, chromium, iron, manganese and copper, conductivity, color and taste when compared to non-flaring location (Nwankwo and Ogagarue, 2011); on surface and ground water in Irri Town and environs had high content of iron and lead in the water which was attributed to gas (Emumejaye, 2012); rainwater quality in Bayelsa State showed that all the parameters studied including temperature, lead, conductivity, total dissolved solid, nitrate, carbonate, sulphate and pH had values above standards (Ezenwaji *et al.*, 2013). Other effects of acid rain on water quality have been comprehensively documented by Ogunkoya and Efe (2003), Olobaniyi *et al*., (2007), Efe (2011); Efe and Mogborukor (2008); Amadi (2014), etc. The heat from the flare could enhance the temperature of the environment including water. High occurrence of sulphate and nitrate ions may be connected to the emission of carbon, sulphur and nitrogen oxide during flaring activities. The occurrence of ions in the water could lead to high conductivity level in water close to gas flaring location.

Eutrophication

Excessive nutrient enrichment that leads to a cycle of enhanced algal blooms followed by algal death, decomposition and oxygen depletion is a widespread problem in coastal water (Howarth *et al.*, 2000). Addition of nitrogen, the limiting nutrient in most coastal systems, is the usual culprit and by the use of synthetic fertilizers and fossil fuel combustion, humans have increased nitrogen supply to coastal waters of the United States by six-fold on average, but in some coastal areas nitrogen inputs are greater than 15 times background rates (Howarth and Marino, 2016). Over 65% of estuaries in USA are moderately to highly affected by eutrophication (Bricker *et al.*, 2008). Eutrophication can impact systems directly through changes in species composition, as addition of limiting nutrients can cause shifts in competitive hierarchies (Emery *et al.*, 2001) and promotes invasion by non-native species (Williams and Smith, 2007). However, its greatest negative effect is from subsequent hypoxic conditions created by microbial decomposition of blooming algae. Low dissolved oxygen (DO) driven by nutrient pollution has been damaging to estuaries where water circulation is limited and oxygen replenishment is slowly.

Globally, the number of dead zones has approximately doubled each decade since the 1960s (Diaz and Rosenberg, 2008). Low DO can cause changes in growth, metabolism, and mortality of marine organisms, with sensitivity declining from fish, to crustaceans, to mollusks (Grey *et al.*, 2002). However, mobile organisms are better equipped to survive hypoxic events by migrating, while sessile habitat-forming species can be most heavily impacted (Altieri and Witman, 2006). Ecosystem level effects of hypoxia include compressed habitats, loss of key fauna, and diversion of energy from higher trophic levels to microbial pathways as organisms die and decompose (Diaz and Rosenberg, 2008).

Plastic Pollution

Plastics are often light, cheap, and durable materials; causing such litter to accumulate in land fills, or to be transported from source areas to sinks like the ocean. Because they can usually be cheaply produced, they are generally used only once and are then thrown away as litter. About 49% of all produced plastics are buoyant, which gives them the ability to float, and thereby travel on ocean currents to any place in the world (Environmental Protection Agency, 2008). A good understanding of the transport and fate of plastics in the ocean can be gained by

categorizing and monitoring the movement of plastic debris.

Origin of Plastics in the Marine Environment

The release of plastics into the environment is a result of inappropriate waste management, improper human behavior, or incidental pollution (Barnes *et al.*, 2009). Well-operated land fills are closed systems: daily covered by soil or synthetic materials and are surrounded by fences to hold wind-blown debris in place. Plastics do not biodegrade and can remain in place for centuries, until they are burned or used for recycling. The portion of plastic litter that does not reach landfills will roam the earth's surface, travelling by wind until it reaches the rivers, and eventually the oceans. Improper human behavior produces such waste, when plastics are abandoned or are dumped outside licensed collection points or at sea. Incidental pollution also occurs, and includes the loss of containers at sea (Barnes *et al.*, 2009).

1.)Ocean-Based Sources

In highly populated areas, land-based sources dominate the input of plastic waste into the marine environment; ship-generated debris is the major source of marine debris found on remote shores. Furthermore, eight million items of marine litter are estimated to enter the oceans and seas every day through various sources (United Nations Environmental Programme, UNEP, 2005). Nearly 5.6 million tons of marine debris every year is estimated to come from ocean-based sources, which is 88% of the total marine debris input. Daily, about five million items of solid marine debris are estimated to be thrown overboard or lost from ships (UNEP, 2005). The main ocean-based sources of such waste according to (Sheavly, 2005; United Nations Environmental Programme, UNEP, 2001) are ; a.) Merchant Ships, Ferries, and Cruise liners b.) Naval and Research Vessels c.) Pleasure Craft d.) Offshore Oil or Gas Platforms e.) Fishing Vessels

Most ocean-based marine litter is probably represented by abandoned and lost fishing gear. In areas far away from urban development, discarded fishing gear is responsible for 50–90% of the total marine debris (UNEP, 2005). Among the different forms of discarded marine debris from fishing vessels are fishing nets, fishing lines, fish boxes, crab and lobster pots, oyster nets, strings for packaged bait, rubber gloves and of course household waste, oil containers, and sewage. There are several reasons fishing gear can become marine litter: i.) Fishing gear is abandonedji.) Fishing gear is discarded
iii.) Fishing gear is lostv.) Containers are lost

2.) Land-Based Sources

Approximately 0.8 million tons annually of marine debris, which is 12% of the total debris input into the oceans, originates from land-based sources, and primarily consists of discarded plastic items (user plastic). In highly populated areas, marine debris comes primarily from the land. Main land-based sources of marine debris are as follows (Sheavly, 2005; UNEP, 2007). a.) Municipal Land fills Located on The Coast b.) Discharge of Untreated Sewage and Storm Water , c.) Industrial Facilities d.) Tourism

Impact of Plastics on the Marine Environment

The properties that make plastics such desirable materials for modern society can make them lethal for wildlife, when introduced into the environment. Numerous species are affected by plastic pollution, primarily because organisms become entangled in plastic nets, or plastic objects are ingested when organisms mistake plastic debris for food (Laist, 1997). Also, plastic facilitates the transport of species to other regions; alien species hitchhike on floating debris and invade new ecosystems, thereby causing a shift in species composition or even extinction of other species. Plastics also transfer contaminants to the environment or to organisms when ingested. In addition to impact

on marine life, plastic debris can also damage marine industries (entangling propellers and blocking cooling systems). It has been estimated that marine debris damage to the marine industry in the Asia-Pacific region costs $1.26 billion annually (Mcllogrm *et al.*, 2011).

1.) Mechanical Impact

At least 267 marine species worldwide suffer from entanglement and ingestion of plastic debris (Laist, 1997). When such contacts occur, organisms are seriously affected in ways that quite often results in death.

a.) Entanglement

A total of 136 species are being affected by marine debris entanglement (Laist, 1997). Entanglement can cause death by drowning, suffocation, strangulation, or starvation (Allsopp *et al.*, 2007). Very often, birds, small whale species, and seals drown in ghost nets, lose their ability to catch food, or cannot avoid predators because of their entanglement (Derraik, 2002).

i.) Coastal and Marine Birds

Many birds in the marine environment dive for food, and thereby come into contact with plastic debris. The greatest causes of entanglement by seabirds are fishing lines and six-pack rings. Both materials are often transparent and difficult to see. If seen, they can be mistaken for jelly fish and other food (Allsopp *et al.*, 2007) .

ii.) Seals

Many seal species are curious and playful, and especially young seals are attracted to plastic debris and swim with it or poke their heads through loops. Plastic rings, loops, or lines easily glide onto the seal's neck, but are difficult to remove due to the backward direction of the seal's hair. As the seal grows, the plastic collar tightens and strangles the animal or severs its arteries.

iii.) Fish Species and Ghost Fishing

The incidence of accidental entanglement of fish species is difficult to estimate, because certain fish are "intended" to become entangled in nets. Entanglement of fish species is caused by ghost fishing resulting from fishing gear that continues to function in the water after being discarded or lost (Shaw and Day, 1994). Fishing nets and pots can capture marine organisms, which subsequently die if they cannot escape. In turn, these organisms attract larger predators which also become trapped. When the larger organisms die, they attract smaller scavengers, and so the cycle continues. These fishing nets and pots are death traps for marine organisms, because they do not biodegrade, but rather continue to " fish" for many years.

iv.) Sea Turtles

Sea turtles are well-known victims of plastic debris. Juvenile specimens are easily caught in discarded fishing nets, and succumb by drowning. Larger sea turtles are still able to swim with fishing gear attached to their fins or shell, but the debris often affects their ability to feed in ways that eventually results in starvation. Plastic debris and other human activities have a big impact on these species worldwide, because six out of seven sea turtle species are known to be affected by entanglement (Laist, 1997).

b.) Ingestion

Plastic debris that pollutes the marine environment is often ingested by marine birds, mammals, turtles, and fish (Laist, 1997). The ingestion of plastics primarily occurs when it is mistaken for food, but can also occur from incidental intake. The ingested material often consists of micro- and meso-debris sized fragments, which sometimes are able to pass through the gut without hurting the organism. In most cases, however, fragments become trapped inside the stomach, throat, or digestive tract and cause damage (e.g., sharp objects) or a false sense of fullness, which will result in starvation.

i.) Coastal and Marine Birds

A high proportion of coastal and marine bird species ingest plastic fragments (Laist, 1997). Although plastics are mainly ingested by birds because they are mistaken for food, they may also already be present in the gut of their prey, or may be passed from adult to chick by regurgitation feeding. Some species feed selectively on plastic fragments that have a specific shape or colour (Moser and Lee, 1992). Therefore, plastics ingestion by birds is directly related to their feeding habits and foraging techniques. Birds that consume fish (piscivores) are less likely to ingest small plastic fragments than birds that primarily feed on plankton (planktivore); the latter often confuse plastic pellets with their prey (Derraik, 2002).

ii.) Seals

Ingestion of plastic fragments is far more commonly reported for birds than for seals. The reason for this may also result from the small sample size prevalent in seal studies. A total of 164 plastic fragments, mostly polyethylene (93%), were found in the gut of 145 seals, which is more than one fragment per seal. All fragments consisted of user plastics. According to the otoliths, and compared to plastic ingestion by fish in other studies, these fragments were probably not directly ingested by the seals, but rather were accumulated in the fish they consumed (Eriksson and Burton, 2003).

iii.) Whales

Most whales that ingest plastic debris live in remote areas and may sink after they die. Most whale species are protected, makes it difficult to study the incidence of plastic ingestion by whales. The sample size is often very small, and is limited to specimens that have been washed ashore. Nevertheless, if one specimen is found to be affected by ingestion of plastic debris, it is probable that other individuals from the same species run comparable risks. Plastics were found to have blocked the digestive tract, resulting in the accumulation of bones, half-digested fish and intact fish in the digestive track. The harbor porpoise died from starvation (Baird and Hooker, 2000), after ingesting a corn chip bag, plastic sheets, a garbage can liner, and a bread wrapper while ingestion of a bundle of plastic threads (Derraik, 2002). A sharp increase in the occurrence of ingested plastic debris was found in younger dolphins during their weaning phase. Such dolphins may have misidentified what constituted food, or plastic debris, because they had yet to learn what is and is not edible (Denuncio *et al.*, 2011) .

iv.) Fish

Plastics ingestion by fish has received little attention, with most reports recording only incidental ingestion events. Tiger sharks are known to ingest various items of plastic debris, including plastic bottles, caps, bags, and foil (Randall, 1992). Some larval and juvenile fish species were found to have plastic pellets or fragments thereof in their guts. In addition, some adult species had a wide range of material in their guts, from plastic fragments to whole plastic cups.

v.) Sea Turtles

Sea turtles are among the marine species which are most threatened by plastic debris. Sea turtles do ingest plastic debris (Bugoni *et al.*, 2001; Derraik, 2002). Plastic debris, like bags and sheets, is often transparent and can be mistaken for jelly fish, which is a key diet item for most sea turtles. Sea turtles are endangered species, and if plastic intake increases their mortality, the consequences for sea turtle populations around the world may be quite serious. The ingested materials were comprised mostly of plastic bags and white or colorless plastic pieces (Bugoni *et al.*, 2001). Loggerhead turtles are predators and

display little prey discrimination while foraging. This was confirmed by a large variety of plastic items of different colours and shapes found inside their digestive tracts (Thomas *et al.*, 2002).

Acid rain

The effect of acidification has been sighted all over the world with deleterious ecological effects such as reduced reproduction of aquatic fish species, dieback and stunted growth in plants, accumulation of toxic aluminum and heavy metals in soil and water bodies, biodiversity loss including corals and shellfish, degrade to the manmade structures made up of marble and stone and corrosion of metal structures (Arti *et al.*, 2010). Acid rain caused by emission of SO_2 and NO_x from various sources to the atmosphere and they dissolve in atmospheric water and produce acids in the rain water (Asthana and Asthana, 2001; USEPA 2012). Release of toxic heavy metal ions such as ions of copper, cadmium, nickel, chromium, cobalt, lead and zinc in the water body reduces the development and growth of the fish. Acidic condition together with toxicity of heavy metals reduced the growth of the fish and increases the stress, this make the fish less immune, thus become more susceptible to diseases, kills the eggs and larval stages, reduces spawning and reproductive success (Asthana and Asthana, 2001).

Acidification effects shell forming mollusks, shell fish, coral reefs, sea grass beds and juvenile stages of aquatic organisms. In case of shell fish and corals, their calcareous shell or skeleton get dissolved in acidic environment. Reduced pH encourages the growth of acid tolerant forms such as some bacteria and protozoa. Acid rain is not the sole cause of acidification, some swamps, bogs and marshes naturally have low level of pH. In addition, acid water runoff from coal mines could reach the surface waters bodies causing fish kills (UNEPA, 2011; 2012).

Urbanization

The human population of the earth continues to grow, with most of that growth occurring by expansion of existing urban areas. The resulting conversion of rural land to urban land uses will affect associated streams. The world's ecosystems provide a wide range of essential and economically valuable services (Booth, 1990). Aquatic ecosystems provide a wide array of such services, including freshwater for agricultural, industrial and municipal uses, transportation corridors, food, opportunities for recreation and esthetic enjoyment, and waste disposal (Petts, 1989). As human populations grow, their effects on aquatic ecosystems have increase (Cottingham *et al.*, 2004) and the world's urban population is increasing at a faster rate than the total population. Almost all population growth in the next 30 years is expected to occur by expansion of existing urban areas (UNEP, 2004). The report shows that the world's urban population was estimated to be 3 billion in 2003 and is expected to increase to 5 billion by 2030. As rural lands surrounding urban areas are converted to urban land uses, nearby freshwater systems experience increased stresses with a variety of consequences for biodiversity and ecosystem processes (Erickson *et al.*, 2005; Field and Pitt, 1990). Urbanization can change the chemical and physical properties of stream systems (Finkenbine *et al*., 2000; Diebel *et al.*, 2005). Large areas of impermeable surface can increase the frequency and magnitude of storm flows (Fraker *et al.*, 2002). Excessive groundwater pumping and reduced recharge lessen base flow and can exacerbate the effects of droughts. Modification of stream hydrology and flood management practices can alter the sediment regime, with subsequent effects on streambed composition, and stream channel morphology (Fitzpatrick *et al.*, 2004). Loss of riparian vegetation can increase water temperatures as stream shading is reduced, reduce habitat structure for fish (Huckins *et al.*, 1993; Karr, 1991), and change trophic processes (Ambrose, 2005).

Concentrations of nutrients, pesticides, organic chemicals, and heavy metals are often elevated in urban runoff and treated waste water, which are major sources of water in many urban streams (Chang and Tracy, 2005). These changes in physical habitat and water quality have been linked to changes in aquatic biota. Urban storm water runoff has been recognized as an important factor affecting biota (Klein, 1979), as have hydrologic and land use changes associated with urbanization (Booth, 1990). Understanding the effects of these stresses on aquatic assemblages will be extremely important in preserving, rehabilitating, and managing these ecosystems as urbanization proceeds (Ambrose, 2005; MacCoy and Blew, 2005).

Use of impervious surface has been especially favored because it is linked to changes in stream hydrology, which affect stream biota and a variety of stream processes (Martin *et al.*, 1986; Pickett, 1990). However, urbanization clearly has a variety of interacting effects on stream ecosystems that may be further influenced by regional and historical differences in urban development and natural factors such as climate, physiography, geological setting, vegetation, and soils (Karr, 1991, UNEP, 2001).

Fig. 2 shows the world's rural and urban population from 1950-2050.

Conclusion

The growth of human population has immensely affected the aquatic environment by increasing the activities of humans which pollute, deplete and destroy the aquatic ecosystems. Pollution of water is an environmental problem that is of major concern to the world. Human's contributions to water pollution are enormous by ways of dumping of refuse, industrial wastes and washing of clothes, etc. and engaging in activities which indirectly affect the aquatic ecosystem such as indiscriminate use of fertilizers and pesticides, exploitation of natural gas and oil which result in gas flaring and oil pollution respectively and so on. Compounding the problem of overfishing, millions of aquatic animals are accidentally killed and thrown away as bycatch, an astounding 20 million tons of birds, fish, marine mammals, and sea turtles are accidentally caught in trawl fishing nets, long lines and drift gill nets each year. To this effect, reduced consumption, better regulation, better fisheries management and new technologies can help some species rebound, but in the long run, much of this progress will be undermined if the human population and its voracious appetite keeps growing unsustainably

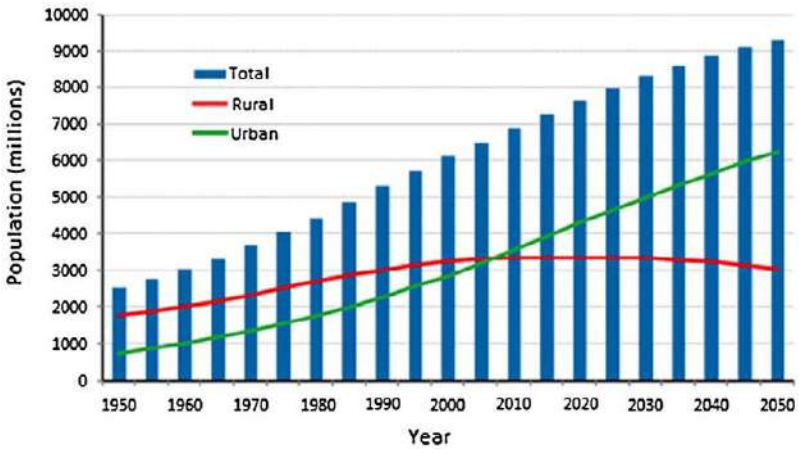

Fig. 2: The world's urban and rural population, 1950-2050 (Source: World Urbanization Prospects, 2014).

Recommendations

1. Therefore, a population-controlled policy that respects basic individual rights, sound resource use policies, and the support of science and technology to enhance energy supplies and protect the integrity of the environment is needed in order for an optimum population to be achieved.
2. Policy makers and other stakeholders need to come up with an optimal solution to combat overfishing. They should educate the fishermen, marketers and even consumers on the need for sustainable fishing.
3. Federal, State and Local Government should establish agencies to monitor our environment and equally be sure that our environment is kept clean and free from refuge dumps and chemicals that can adversely affect the aquatic habitats.
4. Industrial, homes or families should equally inculcate a hygienic environment particularly in their vicinity. Our industries should go advance in trying to recycle these wastes instead of dumping them for rain water to sweep them into the streams, rivers and oceans.
5. It is very important to continuously monitor and control the local environment. This validates a need for: monitoring microclimate of crops to prevent onset of moulds and other diseases, and a mechanism to control chemical laden water into or out of a farm preventing contamination of its own or other's farm or water bodies.
6. Environmental education is of immense importance to use particularly in schools, organizations, industries and rural areas. In this way, humans will be less inclined to pollute the waters and deplete its resources.

Acknowledgements

The author is grateful to Miss Joy Nnenna Ajah, who volunteered information for this work. Dr. Ambrose E. Eyo, the then Head of Department of Fisheries & Aquatic Environmental Management, University of Uyo, Uyo is also appreciated for interest expressed.

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Determination Of Water Quality And Microbial Parameters In Untreated Municipal Sewage Impacted Sections Of Iwofe Creek, Niger Delta, Nigeria

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Abstract: *The impacts of untreated municipal sewage on the water quality and microbial parameters of Iwofe Creek, Niger Delta, Nigeria were studied between October 2021 and March 2022. Samples were collected from three different points in the Creek known to be affected by the sewage effluents and data generated were analyzed using the Ducan Multiple Range test to determine if there are significant differences between the mean values of parameters sampled at the different points at a probability level of 0.5%. The parameters studied included pH, turbidity, Ca, temperature, TDS, dissolved oxygen, salinity, electrical conductivity, nitrates, sulphate, chloride, hardness, alkalinity, BOD_5, magnesium, calcium, Total Coliform Count, Faecal Coliform Count, Total Heterotrophic Bacteria Count, Total Heterotrophic Fungi Count, Total Hydrocarbon Utilizing Bacteria, Total Hydrocarbon Utilizing Fungi were determined. The pH, temperature, salinity, nitrate, alkalinity, BOD, TCC and FCC ranges were recorded as 7.21-7.33, 26.14-32.12, 4.53-7.36, 1.65-2.20, 67.33-80.24, 42.67-63.00 and 23.33-29.00 respectively. The mean results of physicochemical parameters; pH, turbidity, BOD, THBC, TCC, FCC, Ca, Mg, THUB and THUF were higher than the permissible WHO limits, while temperature, salinity, conductivity, dissolved oxygen, phosphate, sulphate, nitrate and TDS were either below or within the regulatory limits of WHO. The microbes showed varying degrees of correlation with different levels of physicochemical parameters. Awareness creation is needed on simple methods of household-water treatment. For fisheries resources conservation enhancement, all major anthropogenic activities that are observed to be releasing untreated effluents into the water should be properly regulated, amidst ensuring other remediation measures that would generally reduce the impacts of pollutants on water quality of Iwofe Creek.*

Keywords: Determination, Water Quality, Microbial Parameters, Untreated Sewage, Iwofe Creek, Niger Delta

CITATION:

Akankali, J. A., Davies, I. C. and Sayeh, U. I. (2023). Determination of Water Quality and Microbial Parameters in Untreated Municipal Sewage Impacted Sections of Iwofe Creek, Niger Delta, Nigeria. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp 87- 100

Introduction

The most aquatic ecosystems around the world, especially rivers, lakes, and reservoirs, have been polluted by untreated sewage/wastewater, mining waste, industrial wastewater, agricultural waste and other pollutants (Okere *et al*., 2021), such pollution is caused by extensive industrialisation, increasing population density and high urbanised societies (Akpor and Machine, 2011). The disposal of untreated or poorly treated sewage into surface water bodies in urban areas is common in most developing countries, including Nigeria. This is mainly as a result of poor sanitary practices, week

regulations and outright ignorance on the part of the masses.

Discharge of untreated or partially treated sewage water in surface water body, can lead to contamination of upper soil surface, sewage drainage facilities, surface water and ground water pollution. Excess nutrient enrichment of aquatic wate bodies from any form of organic wastes, including untreated sewage often results in eutrophication. According to Eynard and Walther (2000), eutrophication leads to algal bloom and plant growth in streams, ponds, lake, reservoirs and estuaries and along shorelines. In lakes, rivers , streams and coastal waters where large algal blooms are present, the death of vast numbers of phytoplankton that make up the blooms may smother the lake bottom with organic material (Musia *et al.,* 2015) , The decay of this material can consume most or all of the dissolved oxygen in the surrounding water, thus threatening the survival of many species of fish and other aquatic life (Mbewele 2006), sewage effluent also poses a great burden in terms of wastewater management and can consequently lead to point source pollution problem, which not only increases water treatment costs considerably, but also introduces an under range of chemical pollutants and microbial contaminants to water source (Amir and Tarhan, 2004) . All these effects of improper discharge of sewage effluent into surface waters will ultimately reduce the potential of such water bodies as useful water resources. According to Edokpayi and Osimen (2019), urban areas in most developing countries do not have several wastewater management systems, some of which are very effective and meet international standards, but many others are plagued with poor design, maintenance problems, and expansion including poor investment in wastewater management systems. Therefore, the current study aims at determining the impact of untreated municipal waste product on the water quality of Iwofe creek, one of many such comparatively smaller water bodies (creeks and streams), but critical components of the Niger Delta aquatic resources. Onyeche and Akankali (2013), reported that aquatic environmental studies focusing on physicochemical parameters studies of inland water systems within the Niger Delta have focused mainly on major rivers with little attention on comparatively smaller water bodies (streams and creeks), despite their abundance and importance in the region and entire Nigeria nation. Iwofe creek is one such water bodies considered with triviality with triviality, even though it had been a very important aquatic resource for both domestic water use and aquatic flora and fauna supply (mainly fish protein) for the local residents, until it's potentials in these regards became heavily degraded by pollutants. Consequently, it has therefore become imperative for studies focused on determining the environmental parameters of the inland waters of the Niger Delta to be carried out, with a view to establishing their base characteristics. The results from such studies would form a basis for judging the st**a**te of such inland waters, when compared with what the ideal should be.

Human activities can signify affect the surface water quality due to the growing pollutants loads of different origin (Pursaheb *et al.,* 2014). Among point sources, untreated municipal sewage has been identified as the most hazardous to water ecosystems due to large amount of its nutrients and organic contents (Collins *et al*, 2018) and according to (Gucker *et al.*, 2006), increased nutrient loading and organic matter into the ecosystem can lead to eutrophication, temporary oxygen deficient, alteration of energy relationship in the stream and disruption of biotic community structure and function. Although assessment of river health are widely based on the use of macro invertebrates as indicators, bacteria and other microorganisms may also be informative of the conditions of aquatic ecosystems, most importantly bacteria are responsible for

biogeochemical transformation such as nitrification and denitrification and thus the impacts of stress and disturbance upon microbial communities can have implications for ecosystems functions, and processes as well as biodiversity and aquatic community structure (Steven *et al.*, 2008).This research is expected to provide awareness and information on determining the impact of untreated sewage on the aquatic environment and its impact on microbial. The essence of this research is to determine the impact of untreated waste, through the physiochemical analysis on the water and analysis on the microbial profile and the possible ways to reduce the various activities that pollute the water and the effluent from the septic tanks that is discharged into the river and hinders the growth of aquatic organism. This study attempts to provide information on the physiochemical characteristics of Iwofe Creek as well as the response to the untreated municipal sewage discharges.

Study Area

The sections of Iwofe Creek studied are located at latitude N 4°48'6.365" and longitude E 6°56'24.362", in Iwofe Community of Obio-Akpor L.G.A of Port Harcourt, Rivers state, Nigeria. The area has a gentle slope from terrestrial marshy wetlands towards the coastal shores of the Atlantic Ocean. The climate has two prevailing seasons: dry and wet. The natural vegetation is tropical rainforest, dominated by nipa palm and white mangroves, with scattered patches of farmland. The Creek has shallow depths due to anthropogenic activities, such as the dumping of untreated municipal sewage and industrial effluents, sawmilling dust, animal and human waste, and hydrocarbon deposits. Sewage is the major pollutant, causing foul-smelling, turbid, and heavily polluted water. The aquatic flora and fauna, including economically important fish, have been adversely affected, and the socio-economic uses of the water have been hampered. The study area has three sampling stations.

Materials and Methods

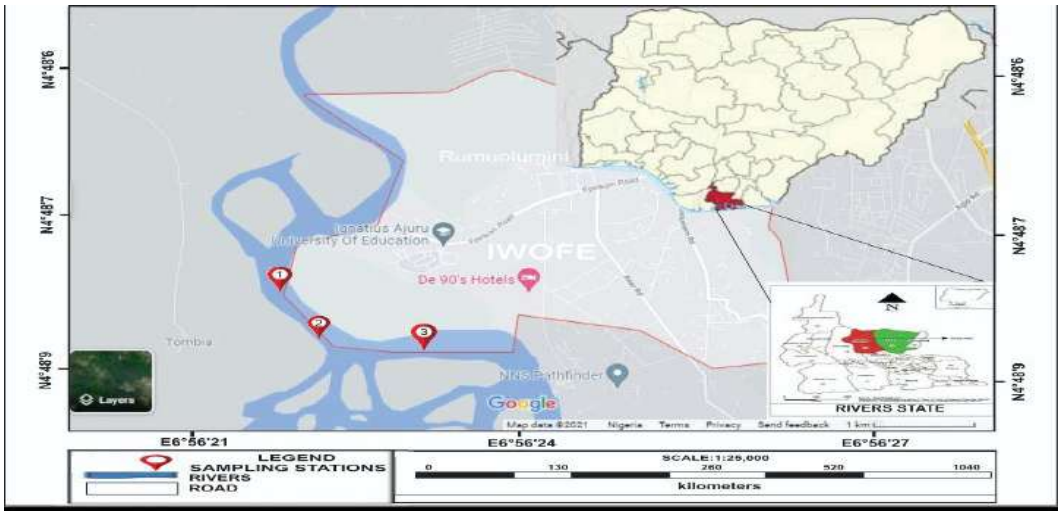

Fig. 1: Map of Study Area showing sampling points along Iwofe Creek, Obio-Akpor L.G.A, Rivers State, Nigeria *(Source: Adapted from Google Earth Map)*

Description of Sampling stations

Sampling was carried in three different stations that were about 500- 1000 meters apart, along the Creek of the study (Fig.1). Site 1 (upstream) is located at the main point of raw sewage discharge into the Creek, (latitude N4°48'6.365" and E6°56'24.362"). There is a landing site, that is where the septic truck tank lands, and a pipe is

connected to a deep well where the sewage is first discharged. Each of the tanks has a screening net, that filters out most of the debris and other materials, thus relatively large particles of free sewage eventually flow into the creek. The area is characterized mainly by scanty secondary vegetation, dominated mainly by mangrove plants (*Rhizophora racemosa*) and nipa palm (*Nypa fruticans*). Station 2 (midstream) is located at latitude N4°48' 7.602" and longitude E 6°56' 21.183" E. The site is located about midway between sampling stations 1 and 3. Apart from being inundated by untreated sewage effluents flowing from station 1, it also has a lot of significant dumping of human feces and other solid wastes directly by residents of the area. of the sewage discharge. The water in this station is highly turbid due to rampant domestic waste dumping in this creek section. It is also characterized by secondary vegetation similar to that of station 1. The inhabitants of the area discharge waste made of human feces and other materials. Station 3 is located downstream from the Creek (latitude N 4°48'. 943 and longitude E 6°56'18.004). This location is highly built and has civil structures such as concrete drainage slabs. It is more prone to the tidal influence from the river, has a sparse vegetative cover, the water is relatively faster flowing, and contains considerable amounts of green algae. Some domestic wastes such as plastic bottles, cans, cloth, etc. are also indiscriminately dumped in this section of the Creek. The different sections of the Creek that constituted the sampling stations, as shown in Plates 1, 2, and 3 respectively.

Plate 1: Station 1

Plate 2: Station 2

Plate 3: Station 3

Plates 1, 2 and 2; show the upstream, midstream stream, and downstream (sampling stations I, II, and III) sections of Iwofe Creek in the study area. The three different sampling stations were selected and georeferenced based on the different anthropogenic activities along the various sections of the Creek studied. Magellan GPS 315 was used to generate the sampling stations' geographic coordinates (longitudes and latitudes). Sampling was carried out once, within the last week of every month spanning between the months of October 2021 to March 2022.

Sampling methodologies

The equipment used for sample collection includes hand held pH meter (Milwaukee Model pH600), a portable refractometer a hand-held Hanna multi-meter instrument was used for in-situ parameter measurements, a handheld Global Positioning System (GPS) receiver unit (Magellan GPS 315) were used to record the geo-references of the sampling points and an Ekman grab for sediments collection form the bottom of the Creek at the various sampling stations. A surface water sampler was used to collect water samples and poured into sterilized bottles for the determination of microbial parameters of interest. These bottles were properly labelled based on each sample station in Iwofe Creek where they were collected. The water samples collected for heavy metals analysis were collected also with the aid of the surface water sampler and poured into plastic bottles, that

were clearly labelled, in accordance with each sample stations where they were collected. sediments were collected with the aid of Ekman grab and deposited in zip lock polyethylene bags. The physico-chemical parameters (pH, temperature, electrical conductivity, total dissolved solids, turbidity and dissolved oxygen) were measured using a handheld Hanna multi-meter was used in-situ. The meter was first switched on and allowed to stabilize for 10 minutes before the probe was inserted 5cm deep into the surface water and allowed to stabilize before the readings were taken. For the determination of salinity, an in-situ refractometer was uses; the daylight plate was opened and two drops of distilled water were deposited on the surface of the prism and it was cleaned before taking the readings with a method of APHA4500C. The refractometer was placed under the light source and then observed through the eye piece to take readings.

The sediments were collected from the three different sampling stations by lowering it to the bottom opened, and it was then subsequently operated to close, though which mechanism was gathering the bottom sediments as it was pulled up back. The sediments collected were put into a Zip lock bag and properly sealed. All samples collected for further analysis water samples, adequately labelled and immediately transported to the Fisheries Laboratory, Department of Fisheries, Faculty of Agriculture, University of Port Harcourt in ice chest coolers.

Coliform Counts (Total coliform count and faecal coliform count)

Fermentation technique was used to enumerate coliform bacteria. Coliform count and faecal coliform count were determined using APHA9221B method. Total heterotrophic bacteria count (THBC) was determined using APHA9215B method. Total heterotrophic fungi count (THFC) was determined using APHA9610B. The total hydrocarbon utilizing bacteria (THUB) and total hydrocarbon utilizing fungi (THUF) were done in the Laboratory by using a ten-fold serial dilution with normal saline dilution (APHA, 1998)

Results

Physicochemical parameters across months

The result on Table 1 shows that the pH, temperature and dissolved oxygen recorded no significant differences across the different months of sampling. There is no significant difference between the salinity recorded in the month of October (4.53±0.05) and that of March (5.24±0.13). The salinity recorded in the month of December (7.11±0.17), January (7.36±0.21) and February (6.75±0.23) are not significantly different but significantly higher than that of November (5.85±0.05) and October (4.53±0.05). The turbidity was high in the month of January (8.67±0.21), February (8.33±0.33) and March (8.00±0.58). The lowest turbidity was recorded in the month of October (5.67±0.67).

Table 4.1. Also indicated no significant differences between the dissolved Oxygen recorded in each month. Although in the month of March, the highest amount of DO was recorded. in the month of January, the highest amount of TDS (1155.00±238) and the highest amount of EC was recorded.

Table 1: Physicochemical parameters results across months

Months	October	November	December	January	February	March	WHO	FEPA
pH	7.33±0.27	7.38±0.12	8.01±0.42	7.21±0.12	7.73±0.04	7.5±0.31	6.8-8.5	6-9
Temp	28.3±3.5	33.2±3.30	28.5±0.54	26.14±0.6	29.99±2.0	32.1±0.29	24-28^{0}C	NA

EC	476.7±152.1a	323.3±72.2a	900±297.7a	2311±475.5bc	3420.7±90.5b	2130±131.2	2000 (µs/cm)	1000
TDS	223.3±76.9	152.3±32.79	443.3±150.26	1155±2380	1690.7±6.3	1053.3±66.92	500 (ppt)	2000
Salinity	4.53±0.05	5.9±0.27	7.11±0.17	7.36±0.2	6.75±0.2	5.24±0.13	-	0.0-0.01
Turbidity	5.67±0.67	6.3±0.33	8.33±0.33	8.67±0.7	8.33±0.3	8.0±0.58	5 (NTU)	300-1000
DO	5.51±0.83	6.1±0.43	6.2±1.07	5.94±0.7	6.21±0.4	6.4±0.26	3 – 7 mg/l	4

World Health Organisation (WHO, 2011) and Federal Environmental Protection Agency (FEPA, 20). The mean±SE of parameters with the same alphabetic superscript in the same column are not significantly different from each other (p<0.05).

Physicochemical parameters based on stations

Table 2 shows the physicochemical parameters of water across the different stations. Station 2 recorded the highest pH value (7.82±0.20), while station 1 recorded the lowest pH value (7.38±0.17). Although, there was no significant difference recorded between the stations (p>0.05). Station 2 recorded the highest temperature, salinity, pH, dissolved oxygen, and EC. No significant difference was recorded between the three different stations.

Elements and BOD_5 concentrations across months

Nutrients such as nitrate and phosphate no significant differences across months. Table 3 also indicated that the level of phosphate was highest in the month of March 90.26±0.05). Sulphate concentration was also highest in the month of March (130.06±7.80). While the lowest concentration of sulphate was recorded in the month of October (112.6±346). The months of October and November recorded higher BOD_5 (2.80±0.29 and 2.62±0.36) respectively

Table 2: Physicochemical parameters of Iwofe Creek between stations

Parameters	Stations 1	Station 2	Stations 3	WHO (2017)	FEPA (20)
pH	7.38±0.2	7.82±0.2	7.40±0.15	6.8- 8.5	6- 9
Temp	29.41±0.9	31.68±2.0	28.02±1.6	24 - 28°C	NA
EC	1388.5±474.3	1822463.1	1570.33±602.9	2000 (µs/cm)	4µs/cm
TDS	679.83±231.7	915.33±241.9	763.83±293.9	500(ppt)	2000
Salinity	6.19±0.5	6.20±0.5	6.03±0.4	-	0.00-0.10
Turbidity	7.50±0.72	7.33±0.33	7.83±0.65	5 (NTU)	1000
DO	5.96±0.55	6.57±0.29	5.60±0.33	3 – 7 mg/l	>1.00

Means±SE of parameters with the same alphabetic superscript in the same column are not significantly different from each other (p<0.05)

Table 3: Nutrients and other elements concentrations cross the months

Months	October	November	December	January	February	March	WHO Limit FEPA
Nitrate	2.02±0.13	1.65±0.23	2.08±0.07	2.20±0.23	2.07±0.20	2.04±0.03	10 (mg/l) -
Sulphate	112.66±3.46	122.98±7.16	129.49±11.43	120.74±4.55	113.14±3.42a	130.06±7.08	250 (mg/l) 20
Phosphate	0.15±0.04	0.25±0.04	0.20±0.02	0.23±0.06	0.19±0.02	0.26±0.05	0.1 (mg/L) -
Chloride	6879.81±2972.84	1040.37±35.49	1081.80±26.00	1090.60±59.00	1058.43±27.16	1023.92±17.25	250(mg/L) 100
Hardness	911.67±41.21	1102.29±109.54	1012.09±59.44	1010.75±3.30	1017.50±3.25	1026.20±12.70	500 (mg/l) 500
Alkalinity	67.33±0.59	60.60±0.88	75.01±3.27	80.24±0.47b	71.54±3.02	79.44±0.40	- 200
BOD_5	2.80±0.29	2.62±0.36	2.18±0.53	1.99±0.08	2.66±0.61	1.85±0.31	4 (mg/l) NA

Nutrients concentrations across on stations

Table 4 shows the results for nitrate, sulphate and phosphate concentrations across the three stations. All the values for the three nutrients are below the WHO and FEPA limits. Thus, the water of Iwofe Creek could be considered not to have excess nutrient enrichment that could result in eutrophication, despite the huge amount of sewage dumped in it. This situation could be attributed to the fact that the Creek water is not stagnant. Thus, it's continuous flow enhances the transporting away of these nutrients, as against being concentrated in a stagnant water.

Nutrient concentrations across months

Table 5 shows the nutrient concentration of Magnesium and calcium. The lowest concentration of magnesium was recorded in the months of February (347±0.32). The result also shows that there is a significant difference between the concentration of magnesium in the month of December, January and February. The concentration of Calcium is higher in October (984.17±43.10). The lowest concentration of Calcium is recorded in the month of February

Table 4: Nitrate, Sulphate and Phosphate levels across stations

Parameters	Station 1	Station 2	Station 3	WHO	FEPA
Nitrate	2.15±0.06	1.82±0.10	2.06±0.16	10 (mg/l)	-
Sulphate	126.45±4.27	114.84±3.75	123.24±6.11	250 (mg/l)	20
Phosphate	0.24±0.33	0.23±0.02	0.17±0.02	0.1 (mg/L)	-

Means±SE of parameters with the same alphabetic superscript in the same column are not significantly different from each other (p<0.05)

Table 5: Mg and Ca concentration across the months

Months	Magnesium	Calcium
October	938.07±43.13	984.17±43.13
November	864.82±96.23	910.92±96.23
December	428.15±26.92	474.25±26.92
January	382.08±42.71	428.18±42.71
February	347.32±24.09	393.42±24.09
March	595.81±88.90	641.91±88.90
WHO (2017)	7.5mg/l	50mg/l
FEPA ()	200	200

Concentration of Magnesium and Calcium across stations

Table 6 shows the concentration of Mg and Calcium in the three different stations. There is no significant difference between the concentrations of Calcium and calcium across the three different stations. The values of both elements were generally progressively lower form station towards station three. This may be attributable to the higher level of untreated wastes dumped in the station one, being gradually diluted of their soluble fractions as the water transports them farther downstream.

Microbial parameters across the months

Table 7 shows the microbial parameters across the period of the study. The results show that there was no significant difference between the total coliform count of October, November, December, January and March. The faecal coliform count showed no significant differences between the months of October and November but significantly different from that of December, January, February and March. The total heterotrophic faecal count was not significantly different throughout the study period. The total heterotroph bacteria count, total heterotroph utilizing bacteria, count and the total heterotroph utilizing fungi count recorded no significant differences

The microbial parameters across stations

Table 8 shows the microbial parameters across the months. Total coliform count, total heterotroph bacteria count and total heterotroph fungi count are significantly the same relatively to the three stations. Faecal coliform count is higher in station 1, but significantly lower than that of stations 2 and 3.

Table 6: Concentration of Magnesium and Calcium in the three different stations

ELE.	Station 1	Station 2	Station 3	WHO Limit (2017)	FEPA
Mg	563.91± 122.40	617.88±109.39	596.34±98.42	7.5mg/l	200
Ca	610.01± 122.40	663.98±109.39	642.44±98.42	50mg/l	200

Table 7: The microbial parameters across the months

MONTHS	October	November	December	January	February	March	WHO	FEPA
TCC	63.00±4.04	59.00±1.73	58.00±2.51a	60.00±3.05	42.67±18.37	61.00±2.52	0.00	0.00
FCC	27.33±2.40	29.00±1.00	24.33±2.03	24.33±1.85	24.00±1.15	23.33±2.40	0.00	
THBC	1.10±0.05	1.16±0.02	1.07±0.04	1.03±0.04	1.30±0.15	1.47±0.32	0.00	0.00
THFC	3.02±0.09	3.08±0.68	4.31±0.31	3.38±0.56	2.87±0.11	3.05±0.59	0.00	0.00
THUB	2.51±0.36	2.91±0.20	2.41±0.10	2.16±0.55a	2.33±.0.7	2.30±0.27	0.00	0.00
THUF	1.11±0.12	1.24±0.10	0.77±0.27	0.66±0.22	0.74±0.08	0.85±0.08	0.00	0.00 0.00

Means±SE of parameters with the same alphabetic superscript in the same column are not significantly different from each other (p<0.05)

Table 8: The microbial parameters across stations

Stations	1	2	3	WHO	FEPA
TCC	62.17±1.96	58.50±1.76	51.17±9.13	0.00	0.00
FCC	28.33±1.08	23.67±1.22	24.17±1.22	0.00	0.00
THBC	1.10±0.05	1.34±0.17	1.12±0.05	0.00	0.00
THFC	2.90±0.21	3.29±0.42	3.66±0.33	0.00	0.00
THUB	2.46±0.19	2.37±0.23	2.48±0.15	0.00	0.00
THUF	0.82±0.15	0.88±0.15	0.99±0.09	0.00	0.00

Means±SE of parameters with the same alphabetic superscript in the same column are not significantly different from each other (p<0.05)

Discussion

The pH value of any water body is an important index of acidity or alkalinity (Akankali *et al.*, 2019). Several minerals and organic matter interact with one another to give the resultant pH value of the sample. The monthly pH levels of this present study vary from 7.38 to 7.40. It lies within WHO standard limits for a healthy aquatic ecosystem. The normal recommended pH range for a healthy aquatic environment is from 6.5 to 8.5 (Shanks *et al*., 2013). The monthly pH level of the current study also corresponds to that of (Okere *et al*., 2021) which indicated a higher pH value in the month of December, the findings from the current study and that of Ekperusi *et al*., (2016) has shown that the season of the year is a contributing factor to the increase in the pH level. The temperature range was between 26.14±0.6 in January and 33.2±3.30 in the month of November, while some of the readings were within the limits set by WHO, others were slightly above. Temperature exerts a major influence on the biological activities and growth of microbial in an aquatic system (Musa *et al*., 2013). According to Edokpayi and Osimen (2017), temperature influences water chemistry, e.g., DO, solubility, density, pH, conductivity etc. water holds lesser oxygen at higher temperatures (Shanks *et al*., 2013). The temperature of the current study ranges from 29.4 to 31.6^{o}C. However, it should be pointed out that the temperature readings of Iwofe

Creek across the months sampled would normally support aquatic organisms to thrive, since they were not significantly higher than normal.

According to Akankali and Davies (2021), suspension of particles in water interfering with passage of light is called turbidity. Turbidity of water is responsible for the light to be scattered. Turbidity in natural water restricts light penetration thus limiting photosynthesis, which consequently leads to depletion of oxygen content (Deekay *et al*., 2010). The turbidity range of the current study shows that there was accumulation of impurities across stations which indicated the restriction of light penetration and this result is in line with the findings of Musa *et al*., (2013) who indicated the presence of impurities in the water body.

The values recorded for electrical conductivity ranged between 323.3±72.2a - 3420.7±90.5. The conductivity values recorded for the months of October to December which is within the rainy season in study, were within the WHO and FEPA approved limits, while the values for the months of January to March were all slightly above the same limits. This can be explained by the phenomenon of higher concentration of salts in water in the dry season than in the rainy season, due to the lesser volume of water in the Creek during the dry season. A high value of EC generally means high degree of salinity (Okere *et al*., 2021). Therefore, EC is considered as an important water quality parameter in assessing drinking water as well as irrigation water. EC is a widely used indicator for salinity and this has also been used to classify the water under medium saline, low and high saline water (Deekay *et al*., 2010).

The TDS concentration ranged from 290 to 530mg/l. The higher concentration of TDS in above sampling location may be attributed to leaching of chemicals/ions due to improper disposal of solid waste, contaminating surface and ground water quality of Iwoefe Creek. Ammonia nitrogen is an indicator of organic contamination (Edokpayi and Osimen. 2019). In combination with elevated chloride, it could indicate the presence of landfill leachate. Chloride in the groundwater samples ranges from 49.63 to 84.37mg/L. According to Bureau of Indian Standard (BIS) the maximum permissible limit for chloride in drinking water is 250mg/l.

The present study shows the values are within standard limits. In the present study, the amount of sulphate ion is estimated to vary from 114.84 to 126.45.5mg/l. The maximum tolerance range for sulphate is 200-500mg/L. The excess amount of sulphate causes diarrhea (Ekperusi *et al*., 2016). The total hardness is an important parameter of water quality whether it is to be used for domestic, industrial or agricultural purposes (Akpor and Muchie, 2011). Sulphate in water containing calcium forms hard scale in steam boilers. In large amount, sulphate in combination with other constituents gives a bitter taste to water and also acts as formatives in humans (Pantak, 2010).

The dissolved oxygen concentrations of Iwofe Creek recorded during the study is within the WHO standard of 3.0 – 7.0mg/L. DO is one of the most important parameters. Its correlation with water body gives direct and indirect information e.g., bacterial activity, photosynthesis, availability of nutrients, stratification, DO corrode water lines, boilers and heat exchangers at low level and at comparatively lower levels aquatic organisms cannot survive (Steven *et al*., 2008). Variation in dissolved oxygen might be due to temperature, photosynthesis, respiration, aeration, organic water and sediment concentration (Mbewele, 2006).

Chloride and phosphate exhibited a negative relationship with the months as both parameters fluctuate as the months progressed. The range of values for chloride (1023.20 – 6879.81mg/L) and phosphate (0.15 – 0.26mg/L) exceeded the limits set for each respective character by WHO. If levels of phosphate become too high, plant growth can accelerate

resulting in the dense growth of algae and plants in the water body (Okere, *et al.*, 2021). In contrast, Sulphate increased as the months progressed indicating a positive relationship with the months.

The mean values of salinity measured in the present study indicated a progressive decrease with relation to the months. This progressive decreasing trend in the salinity reading of the Creek as the month progressed, can be justified by the sampling period spanning from the rainy season towards the dry season; implying a decreasing volume of water in the creek in the creek for dilution effects of the salinity as the sampling period progressed form the rainy to dry season. There is no set limit for this parameter by WHO, however the range reported in the current study (6.03 – 6.20.00ppm). This salinity reading is normal for a freshwater ecology and the very low values recorded from this study is indicative of the fact that the sections of Iwofe Creek sampled has very little or no saline water intrusion from the ocean. It is also a good indicator of the kind of flora and fauna species that are expected to naturally inhabit the creek would be predominantly fresh water species.

The BOD_5 readings of the Iwofe Creek in October and November recorded higher BOD_5 levels (2.80 ± 0.29 and 2.62 ± 0.36) respectively, which were below the acceptable values by WHO standard of 4mg/L. High biological demand indicates a higher microbial load in the water and as a result of this may lead to the decrease of oxygen in the water. This implies that the BOD_5 level of Iwofe Creek water is ideal for the thriving of aquatic fauna.

The hardness values were recorded between 911.67 to 1102.29 mg/L. The hardness results of the Iwofe Creek water form this study shows a higher value compared to WHO standard. It is indicative of a high incidence of pollutants, especially of substances containing carbonate elements, being deposited and dissolved in the water of the Creek.

The concentration of magnesium and calcium in the three stations shows a higher value compared to the WHO standard of 50 and 70mg/l respectively. According to a study by Pantak (2010), sulphate in water containing calcium forms hard scale in steam boilers. In large amount, sulphate in combination with other constituents gives a bitter take to water. Also, it acts as formative in humans (Rogowska, 2019).

Alkalinity of water is its capacity to neutralize a strong acid and it characterized by the presence of all hydroxyl ion capable of combining with the hydrogen ion (Ekperusi *et al.,* 2016). The various ionic elements that contribute to alkalinity include bicarbonate, hydroxide, phosphate, borate, and organic acids (Edokpayi and Osimen, 2017). The bicarbonate alkalinity is expressed as a total alkalinity, which ranges between 60.60 to 80.24 mg/L. However, slightly abnormal values of alkalinity are not harmful to human beings (Okere *et al*., 2021).

The value of nitrate recorded ranged from 1.65 to 2.07mg/l. All the samples' values are within the range set by WHO, who's set a limit of 10mg/l nitrate for drinking water to prevent the disorder of methemoglobinemia (Ekperusi *et al.,* 2016). Though the nitrate values are within the Creek are normal, all nitrate enhancing substances in wastes should be carefully managed before disposing into the Creek to avoid a spike in its values over time.

Microbial parameters include: TCC -total coliform count, FCC -faecal coliform count, THBC –total, Heterotrophic bacteria count, THFC -total heterotrophic fungi count, THUB- Total Hydrocarbon Utilizing Bacteria, THUF -Total Hydrocarbon Utilizing Fungi. The result from the current study shows the high level of microbial concentration in Iwofe River across months and stations. According to WHO (2017), the presence of an excessive number of biological parameters in the water sources affects human health- the higher concentration of chemicals and deviation

from various biological parameters are a health hazard.

The total coliform count includes bacteria that are found in the soil, in water that has been influenced by surface water in human or animal waste. The high number of coliform bacteria in the water source is a concern for the state, as increased coliform in the source can become a reason for the proliferation of other opportunistic waterborne pathogens. Coliform generally forms bio-film at the site and provides the anchorage and proliferation site for the opportunistic pathogens (Akankali *et al*., 2019). The high level of coliform concentration as indicated y this study is attributed to untreated sewage dumped into the water, which definitely contains human faeces, a very potent source of the coliform bacteria. Boiling drinking water provides effective protection against waterborne microbial pathogens Patnak (2010). Faecal coliform bacteria are a subgroup of the total colifom group. They appear in great quantities in the intestines and faeces of organisms. The faecal coliform recorded in the current study is higher than the limit by the WHO. This high level of faecal coliform indicates the potency of the water body to cause disease. Ekperusi et *al*., (2016) in a similar study also recorded a high of faecal coliform count which is also higher than the WHO limit.

These bacteria make use of organic nutrients for growth. They are universally present in all type of water and their build-up in an aquatic system result in the decrease in the water quality (Deeka *et al*., 2010). The report from the current study shows a high total heterotrophic bacteria count higher than the limit of the World Health Organization (WHO). The result from the current study corresponds to the findings of Okere *et al.,* (2021).

The total heterotrophic fungi count is used to quantify the amount of fungal growth in a particular water body. The drinking water, the WHO standard for total heterotrophic fungi count is '0', while the total heterotrophic fungi count for recreational purposes is <500CFU/ml. This level may increase but count > 500 CFU/ml may indicate a general predisposition of organisms to disease conditions in water (Akankali *et al.,* 2021). The result from the current study shows an increasing level of the total heterotrophic fungi count that may be detrimental to organisms.

The result from the current findings, is higher than the WHO limit for drinking water, which also indicate a high total hydrocarbon utilizing bacteria count. A report by Akankali (2021) and Davies *et al.,* (2021) that researched on same parameters within another water body in the Niger Delta region, also corroborates these findings.

Many substances known to have toxic properties are regularly introduced into the environment through human activities. The current study recorded a high THUF as the other microbial properties. Akankali, *et al.*, (2021) also reported a higher THUF when two water bodies were sampled and analysed for same parameters within the Niger Delta region. The current study showed that there was no significant difference recorded in the microbial load between the different stations and months.

Conclusion

Based on the above findings of the current study, it is expected that the continuous discharge of untreated municipal waste water into the Iwofe River will result in a buildup of microbial load which can be hazardous to both aquatic life and man. Some of the water samples indicated the presence of high level of physico-chemical and nutrient concentrations, which may be due to the improper disposal of solid and untreated municipal waste and leachates from the nearby housing estate and market.

Recommendations

Based on the findings of this research, it is important that the following recommendations are adopted to control pollution and enhance

the optimal functioning of the aquatic habitat/fauna of the Creek.

a. Municipal sewage should be disposed properly to avoid direct discharge into Iwofe Creek.
b. Waste treatment plant should be setup at the current disposal site at the Creek, to ensure wastes are treated to acceptable standards prior to disposal.
c. Advocacy campaigns should be carried out to sensitize all relevant stakeholders within the area of the need to adopt approved standard practices in the way sewage and other wastes should be disposed.
d. Further research should be carried out on the impact of untreated waste on the studied sections of Iwofe Creek, in order to provide updated information on the ecological status of the Iwofe Creek.

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Environmental Sustainability, Agricultural Production And Farmers' Health: The Nexus

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Abstract: *Sustainability of the environment, increased agricultural production and good health of the farmers are some of the major desires of humanity. However, interactions between the environment, agriculture and health, though desirable pose serious threat to each other and require that the linkages be properly and effectively managed for better outcomes. To achieve this, a clearer understanding of the interconnectedness of the trio and their outcomes became necessary. This study therefore x-rayed the interactions between the three sectors, examined the positive and negative effects of the interactions and suggests approaches to quality interconnectedness of the sectors for overall well-being of humans. Findings show that environmental degradation in the forms of air and water pollution, soil nutrient depletion and deforestation are some of the fallouts of agriculture and other activities of humans. These impact negatively on the strength of the soil to support the production of wholesome food materials for human consumption. Consequently, farmer's health and capacity to produce quality food and industrial materials are adversely affected. Cases of diseases, occasioned by unhealthy environment and agricultural activities also abound, including respiratory tract infection, cancer and malaria. In order to regulate these linkages and reduce these negative effects, it is recommended that activities of the three sectors be coordinated by stakeholders in the sectors. Formulation of policies for the three sectors should not be done independently among the three units, but should be a joint activity. Execution of plans for the sectors should be jointly monitored and evaluation should be carried out jointly to identify and correct non-compliance.*

Key words: Environment, Sustainability, Agricultural production, Farmer's health, Linkages

CITATION:
Okoro, G. I. and Umoh, E. E. (2023). Environmental Sustainability, Agricultural Production and Farmers' Health: The Nexus. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 76-86

Introduction

The interconnectedness of environment, agriculture and health is inevitable because, humans depend on the environment and agricultural production for survival. The environment shapes the quality of life of humans, animals and plants. Agriculture depends on, and affects the environment in so many ways occasioned by man's activities, especially in the farm. The environment in turn affects agriculture, while the health status of the farmer affects the manner in which the environment is exploited and the farming system adopted at a particular time. Though natural occurrences play significant role, environmental degradation is a function of human activities, especially, agricultural activities. The linkages among the three do not appear as a one-way flow from one to the next and to the other, but

rather as a web. These interactions among the environment, agriculture and human health create both positive and negative outcomes (Nicolopoulou-Stamati, Maipas, Kotampasi, Stamatis and Hens (2016). In order to reduce the negative, while increasing the positive outcomes, there is need for the three sectors to work together in a coordinated manner.

The connections must be regulated and guidelines set to ensure the achievement of these goals. Therefore, development agents in the three sectors must work together to formulate policies and set out principles to guide these relationships. To achieve this, the linkages and interconnectedness between the three and their outcomes; both the negative and positive must be known.

Intermediary outcomes and their roles in shaping the relationships should also be considered. In order to provide the necessary information on the interconnectedness and their outcome for informed policy formulation and implementation, this paper x-rays the interrelationships among the three and examined their outcome.

For a clearer understanding of the linkages between the three, some salient concepts relating to the linkages need be discussed.

Concept and Components of Environment

To the common man, environment may mean the space within and around a vicinity. But scientifically, environment is made up of the air (atmosphere), rocks and soils (lithosphere), the water (hydrosphere) and living organisms (biosphere). The environment is the medium for plant growth and natural habitat for human. It is the source of water needed for biotic functions, especially the dissolution of minerals and some vitamins needed by the body for proper functioning. Air as a component of the environment is needed for respiratory activities and helps in oxidation of food and chemical substances in the body to release energy needed by the tissues and organs of the body.

Agricultural activities are supported by the soil which provides support to the plants and provides nutrients required by plants for optimum growth and yield. The soil flora and fauna, as major components of the environment help in the regulation and balance of the ecosystem. In order for the environment to perform its functions optimally, it must be properly managed because unguided exploitation of the environmental resources can cause its degradation. It is therefore pertinent to use the environment in a sustainable manner to get the best out of it.

What is Environmental Sustainability?

According to Caldwell (1998), World Commission on Environment defines a sustainable society as one that meets the needs of the present without compromising the ability of future generations to meet their own needs. Environmental sustainability therefore centers on using the environment to meet the needs of the present without jeopardizing the ability of the environment to meet the needs of future generations. Agricultural production depends largely on land, and the quantity and quality of produce from the land is affected by many variables, including the size of the land, soil fertility and extent of pollution of the environment. To sustain the environment, various policies and principles are put in place. These include forest resources protection, whereby individuals and cooperate bodies are prevented from illegal and uncontrolled felling of forest trees, hunting and other illegal forms of exploitation, afforestation aimed at planting trees or replacing any three that is cut down, prevention of bush fire, minimum tillage and crop rotation. Others, according to Okoro, Etuk and Akpan (2016) include application of organic fertilizer, contour cropping and Taunya farming. The environment should be used appropriately

bearing in mind the need to avert activities that may cause its degradation.

Environmental Degradation

Environmental degradation is the deterioration of the environment through depletion of resources which include all the biotic and abiotic elements that form our surrounding; the air, water, soil, plant, animals, and all other living and non-living elements of the environment (Maurya, Ali, Ahmad, Zhou, de Silva Castro, Khane and Ali, 2020). It covers many issues including pollution, biodiversity loss, animal extinction, deforestation and global warming. It is caused by natural and human activities. Natural causes of environmental degradation include flood, drought, climate change, etc. In the same vein, there are many human activities that cause environmental degradation. These include increase in human population, urbanization, bush clearing, burning and other agricultural activities. Pollution of the environment as a form of environmental degradation is caused by many factors. Among these factors are fumes from automobiles and industries, dumping of toxic substances into water bodies and improper disposal of both domestic and industrial wastes.

There are many ways in which environmental degradation can be controlled. It should however be noted that prevention of environmental degradation is better than controlling, because when the environment is degraded, remediation activities may require so much resources and may take a long time to return the environment to its original state. In some cases, it may rather be very difficult, if not impossible to revert the situation. Therefore, to control environmental degradation, many activities and actions should be minimized or prevented. These include minimizing the burning of bio-mass, ensuring proper sanitation at all levels, imbibing best-practices in agro-chemical handling and minimizing the use of chemicals for industrial and agricultural purposes (Ulucak, 2021).

Meaning of Agriculture

Agriculture is the science and practice of farming for the production of food for man and animal, and raw materials for industrial use. It involves the cultivation of the soil and rearing of animals. Agriculture is divided into two broad areas: Crop production and animal husbandry. Cultivation of crops involves many activities. These include land clearing, stumping, ploughing, harrowing, sowing and harvesting. Others are weeding, fertilizer application and application of other agro-chemicals.

There are also many activities in animal husbandry. These include construction of pens, stocking feed formulation and production, pest/disease prevention/control and maintenance of hygiene. All these activities impact significantly on the environment and farmer's health. Care must therefore be taken to abate the adverse effects of these practices on the environment and farmer's health.

Understanding Health

According to Hanna and Cousens (2001), WHO defines health as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity. It is a relative state in which one is able to function physically, mentally, socially and spiritually to express the full range of one's unique potentials within the environment in which one lives (Svalastog, Donev, Kristoffersen and Gajovic, 2017). Health is therefore a multi-dimensional construct which must be considered and interpreted as such. It encompasses the physical wellbeing and transcends the spiritual aspect of man. Besides, the individual must be mentally and socially sound to operate in the environment. Health could be said to be on a continuum which ranges from ill-health to optimum health. The farmer's position on the continuum determines how healthy the individual is and the extent to which the individual can handle the complex

relationships between agriculture and environment to enhance their sustainability.

The Farmers' Health

The world's population is growing at an exponential rate, far above the rate of food production. Therefore, a more technological driven agricultural production strategy can help to narrow the gap between population growth and food production. The effect of technological advancement on increased food production is achieved when the farmers adopt agricultural innovations in the various farming systems. But with sick farmers, the rate of adoption and utilization of these innovations may be slow.

A consideration of the factors of production shows that though land, capital, labour and entrepreneur are the factors of production, entrepreneur, which in this case, the farmer is the coordinator of other factors of production. As the coordinator, the farmer should be in good health condition to operate at optimum level. The health of the farmer therefore, is critical in the production of enough food materials to feed the teeming population. However, often times, the farmer is faced with many health challenges as a result of agricultural activities and environmental pollution. The control of agricultural activities can reduce environmental pollution and the reduction in environmental pollution can enhance farmer's health.

The web-like relationships, if properly coordinated and managed can increase agricultural production and improve the health of the farmer. It is worthy of note that the health of the farmer is an important factor of agricultural production. When the farmer is sick, the quality and quantity of farm labour is reduced, resources for farm work are diverted to settle hospital bills and plan/calendar of activities are distorted. The caregiver's time, energy and other contributions to agricultural production is diverted. Agricultural production and productivity are greatly reduced. It therefore implies that increased agricultural production and environmental sustainability is a function of the ability of the farmer to control and coordinate other factors of production in the farm.

Environment and Agriculture Linkages and their Outcome

Soil, one of the components of the environment is a medium for plant habitation. It provides support and nutrients needed for plant growth. The atmosphere is a source of air to the plants for respiration, while water bodies serve as sources of water to the plants for metabolic activities. The environment provides rain that cools the plants, enhances seed germination and growth. Nutrients are absorbed by the plants as dissolves substances in water. Turgidity of the plant cells and strength for the plant stems are enhanced by absorbed water from the environment. Soil and atmospheric microbes help in decomposition of dead plants and animals, thereby releasing nutrients required by plants for growth and development. During rock weathering, soil particles are formed, while a number of minerals needed by plants are released. This makes the soil fertile for agricultural production. Decomposing biotic components of the soil add to soil fertility. Leguminous plants fix atmospheric nitrogen directly into the soil, thereby making the soil fertile.

Agriculture also has positive effects on the environment. Genetic engineering in agriculture has brought about many species of animals and crop cultivars that naturally did not exist. Some are pest/disease resistant, while some are drought tolerant, which can thrive in regions originally very difficult to exist. According to Killebrew and Wolff (2010) and Carcia (2020), direct effects of agricultural intensification on the environment includes changes in land use pattern, reduction in soil fertility and decrease in biodiversity. Other negative effects of agriculture on the environment include increase rate of soil erosion due to deforestation and

pollution of the environment. Bush burning exposes the soil to erosion. It destroys the flora and fauna components of the environment.

Also, some chemicals used in agricultural production are harsh on the living component of the environment. Continuous cropping reduces the fertility of the soil and sometimes affects the soil structure. There is overgrazing in some areas, while streams are polluted by domestic animals, especially those raised under intensive system of farming. However, the intensity of these effects differs from one geographic location to the other, the type of farming system, the timing of the various activities, land management practices and topographic conditions of the area (Rohila, Duhan, and Kumar, 2017).

Environment and Farmers' Health Linkages and their Outcome

Environment provides the base upon which man lives and also serves as a medium for the production of wholesome food materials for human consumption. The environment could be said to be the fulcrum upon which human existence pivots. A healthy environment is beneficial to the farmer's health in various ways. These include the provision of good quality drinking water, clean air for respiratory activities and serene environment for sports and recreation activities. Good soil enhances the production of wholesome fruits/vegetables and unpolluted water bodies for exploitation of aquatic food materials. The forest is a source of medicinal plants used for the treatment of various ailment. Some mineral elements needed for the growth and proper functioning of human organs and systems are obtained from the environment. Water, a component of the environment aids in digestion and assimilation of food materials. Also, circulation of blood and nutrients is aided by body fluids which contains a very high proportion of water. Forest resources, including plants and animals are food materials for the farmer.

Though environment plays key roles in shaping farmers' health, it has some direct and indirect negative effects on the health of the farmer. Sometimes there is excessive heat, whereby the farmers are subjected to heat stress; there may be drought, making water insufficient for the farmer's use. Floods are also experienced by the farmer, with associated health challenges and economic losses. Air is often polluted with dust particles and sometimes laden with fumes which is dangerous to the health of the farmer. This may cause some health challenges which include respiratory tract infection, air-bone diseases and cardio-vascular diseases. Crops grown on toxic environment may have residues of the toxic materials when harvested. Poorly drained environment may serve as a breeding place for mosquito, which causes malaria. Water-borne diseases thrive as a result of drinking polluted water. Some biotic components of the environment e.g., microbes cause various types of diseases, subjecting the farmer to health challenges.

On the other hand, the environment is adversely affected by the activities of the farmer, especially on the farm. Deforestation is one of the negative outcomes of the interactions between the farmer and the environment. This increases the rate of soil erosion, ecosystem alteration, direct heat of the sun on the soil and destruction of natural habitat of some species of animal. The use of chemicals by the farmer also has some negative effects on the environment. According to U. S. Geological Survey (2007), water-bodies are contaminated when these chemicals are not properly handled or disposed of. The air is also affected, while the soil may be left with toxic materials. Intentional or unintentional bush burning by the farmer destroys many biotic and abiotic components of the environment. The air is filled with fumes and some carbon particles. Most flora and fauna are destroyed in the process and the ecosystem is left unbalanced. To crown it all, global

environmental issues, mainly climate change is caused among other things, by activities of the farmer.

Farmers' Health and Agriculture Linkages and their Outcome

As the world's population grows at an exponential rate, the farmer must be healthy in order to work optimally to match food production with population growth. But poor health reduces the ability of the farmers to innovate, experiment with different farming practices, and capitalize on farm-specific knowledge (Hakes and Ruel, 2006). However, agriculture provides human with the food necessary for nourishment of the body to enhance good health of the farmer and provide raw materials for industrial use (Thomas, 2020). It is worthy to note that the ill-health of the farmer has a huge cost implication on agricultural production. Sick farmers cannot work optimally. The consequence is a reduction in agricultural production and productivity, leading to low farmer's income. Moreover, the area of farmland under cultivation and the number/types of crops and animal raised are also negatively affected. Presenteeism and absenteeism in the farm are common features. These may lead to unplanned turnover and associated cost implication in big commercial farms.

There are many positive effects of agriculture on farmers' health. It is the source of good food materials for the farmer's healthy living. It also produces the fiber needed for making clothing, which protects the farmer from harsh weather conditions, insect's bites and attack by some other harmful organisms. Agriculture provides some of the materials used for the construction of shelter to protect the farmer. It is important to the health of the farmer as a source of medicinal plants for the treatment of some of the farmer's diseases. Agricultural plants, through the process of respiration helps to make oxygen available for human respiratory purpose.

Indirect effects of agriculture on the farmer's health are numerous, one leading to the other. The extent of agricultural production affects farmer's income and the scope of the farmer in making choice of what to eat, the quantity, how and when to eat. It also affects the type of housing, the facilities for comfort and relaxation, and plays important role in affordability of good drinking water. Acquisition of health-related services is also a function of the economic status of the farmer. All these are major determinants of the farmer's health status.

Some agricultural practices also impact negatively on the environment. They cause environmental degradation. According to Malik and Murya (2014) and Yadav, Kumar, Pham, Gupta, Rezania, Kamyab and Talaiekhozani (2019), pollution of the environment as a fallout of agricultural activities poses serious threat to the farmer's health and longevity. Environmental degradation leads to the proliferation of some diseases and health challenges. Example is the prevalence of mosquito in some irrigated areas. The mosquitoes cause malaria that affects the health of the farmer. Heavily polluted soils may lead to the production of poor quality or unwholesome food materials, which can lead to malnutrition or foodborne diseases. Other negative effects of agriculture on farmer's health are the introduction of farm hazards, accidents, bruises and other forms of injuries and zoonotic diseases Diet-related and foodborne diseases are also fallouts of the linkages between agriculture and farmers' health.

Desirable, but indirect effects of agriculture on farmer's health include increased crop yield as a result of fertilizer application, control of pests and diseases with the use of pesticides and prevention of weeds from competing with crops for nutrients through the use of herbicides. However, undesirable consequences of the use

of agro-chemicals according to Nicolopoulou-Stamati, Maipas, Kotampasi, Stamatis and Hens (2016), include an increase in the cost of agricultural production, presence of chemical residues in agricultural produce, and soil toxication, rendering some soils unfit for the production of wholesome agricultural products. All these are detrimental to the farmer's health. Agricultural product processing factories and automobiles emit greenhouse gases. Pungent smell from ill-treated animal droppings and dungs are also perceived, making the air unfit for healthy respiratory activities.

The Confluence

There are many strokes of indirect and direct interrelationships between environment, agriculture and farmer's health. These relationships result in both desirable and undesirable outcomes. Environment is degraded as a result of agricultural activities undertaken by the farmer. Components of the degraded environment including soil, water and air are sources of the farmer's ill-health, while the sick farmer is unable to increase the production of wholesome food materials needed for good health. However, sustainable environment enhances the production of good quality food materials necessary to maintain and improve the health of the farmer. A healthy farmer can operate efficiently, leading to increased agricultural production and efficient management of the environment.

Consequences of Uncoordinated Interactions

The uncoordinated relationships bring about undesirable outcomes or consequences. Among these is environmental degradation, where air, water and land are polluted (Woods, 2018), with reduced potential to support agricultural activities. In the process, plant products are tinted with chemical residue and unwholesomely unfit for human consumption. These agricultural products when eaten by human tend to result in foodborne or food-related illnesses. Direct influences of polluted environment on man are many. According to Kellebrew and Wolf (2010), the air is unfit for respiration; contaminated water bodies unfit for drinking, and heavily polluted or degraded soil unfit for the production of good food materials.

Poor health of the farmer or other consumers of agricultural products is another major undesirable outcome of the unguided linkages. Farmer's poor health condition affects many stages of the produce value chain. The quantity and quality of the produce are adversely affected. Agricultural production and productivity decreased and the keenness at producing quality food and industrial materials are also reduced. The environment is negatively affected as the farmer's strength for proper farm planning, implementation and coordination of the various farm activities are reduced. Appropriate and timely execution of activities in the farm for the maintenance of a balanced ecosystem may not be guaranteed. Daily plan of work and calendar of activities are distorted. Furthermore, the culminating effects of unregulated relationships of the trio is low yield of crops. This may also result in the production of low-quality agricultural products. Farm income is reduced, food security is threatened and the production of care-intensive agricultural crops and animals may be seriously affected. These may lead to poor nutritional status of the farmer, culminating in malnutrition and nutrient deficiency diseases.

Issues of Concern

Sustaining the environment, while increasing the production of wholesome food materials to enhance consumers' health is a problem that must be tackled holistically with multi-sectoral approach. Environmental policies must recognize and in cooperate effects of agricultural practices on the environment. This is with the aim of working with all the sectors to keep the environment healthy. Also, the interrelationship between agriculture and the environment need

be controlled and coordinated. Agricultural policies should be formulated and implemented with the health of the consumers and environmental sustainability as the focus. This should be done while not undermining increased agricultural production and productivity. The farmer, while producing to enhance good health of the consumers, should abhor activities that may degrade the environment. At this point, as observed by WHO (2015), policy makers in the three sectors should not work in isolation, but as a unit working towards achievement of a common goal – quality interconnectedness of the sectors.

Conclusion and Recommendations

The linkages among environment, agriculture and farmer's health result in both positive and negative outcomes. Though with some negative outcome, the interaction is inevitable and should be coordinated and managed to reduce the undesirable effects. In order for agricultural production to thrive and the environment sustained, while not undermining the health of the farmer, it is recommended that activities of the three sectors be coordinated by stakeholders in the sectors. Formulation of policies for the three sectors should not be done independently, but should be a joint activity. Execution of plans for the sectors should be jointly monitored and evaluation should be carried out jointly to identify and correct non-compliance. A periodical re-assessment of the policies should be done by policy formulators. Response team should be constituted and empowered to monitor, detect and respond appropriately to issues arising from the interactions among the three. A periodic meeting of stakeholders should also be undertaken.

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Environmental Sustainability, Agricultural Production And Farmers' Health: The Nexus

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Abstract: *Sustainability of the environment, increased agricultural production and good health of the farmers are some of the major desires of humanity. However, interactions between the environment, agriculture and health, though desirable pose serious threat to each other and require that the linkages be properly and effectively managed for better outcomes. To achieve this, a clearer understanding of the interconnectedness of the trio and their outcomes became necessary. This study therefore x-rayed the interactions between the three sectors, examined the positive and negative effects of the interactions and suggests approaches to quality interconnectedness of the sectors for overall well-being of humans. Findings show that environmental degradation in the forms of air and water pollution, soil nutrient depletion and deforestation are some of the fallouts of agriculture and other activities of humans. These impact negatively on the strength of the soil to support the production of wholesome food materials for human consumption. Consequently, farmer's health and capacity to produce quality food and industrial materials are adversely affected. Cases of diseases, occasioned by unhealthy environment and agricultural activities also abound, including respiratory tract infection, cancer and malaria. In order to regulate these linkages and reduce these negative effects, it is recommended that activities of the three sectors be coordinated by stakeholders in the sectors. Formulation of policies for the three sectors should not be done independently among the three units, but should be a joint activity. Execution of plans for the sectors should be jointly monitored and evaluation should be carried out jointly to identify and correct non-compliance.*

Key words: Environment, Sustainability, Agricultural production, Farmer's health, Linkages

CITATION:
Okoro, G. I. and Umoh, E. E. (2023). Environmental Sustainability, Agricultural Production and Farmers' Health: The Nexus. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 76-86

Introduction

The interconnectedness of environment, agriculture and health is inevitable because, humans depend on the environment and agricultural production for survival. The environment shapes the quality of life of humans, animals and plants. Agriculture depends on, and affects the environment in so many ways occasioned by man's activities, especially in the farm. The environment in turn affects agriculture, while the health status of the farmer affects the manner in which the environment is exploited and the farming system adopted at a particular time. Though natural occurrences play significant role, environmental degradation is a function of human activities, especially, agricultural activities. The linkages among the three do not appear as a one-way flow from one to the next and to the other, but

rather as a web. These interactions among the environment, agriculture and human health create both positive and negative outcomes (Nicolopoulou-Stamati, Maipas, Kotampasi, Stamatis and Hens (2016). In order to reduce the negative, while increasing the positive outcomes, there is need for the three sectors to work together in a coordinated manner.

The connections must be regulated and guidelines set to ensure the achievement of these goals. Therefore, development agents in the three sectors must work together to formulate policies and set out principles to guide these relationships. To achieve this, the linkages and interconnectedness between the three and their outcomes; both the negative and positive must be known.

Intermediary outcomes and their roles in shaping the relationships should also be considered. In order to provide the necessary information on the interconnectedness and their outcome for informed policy formulation and implementation, this paper x-rays the interrelationships among the three and examined their outcome.

For a clearer understanding of the linkages between the three, some salient concepts relating to the linkages need be discussed.

Concept and Components of Environment

To the common man, environment may mean the space within and around a vicinity. But scientifically, environment is made up of the air (atmosphere), rocks and soils (lithosphere), the water (hydrosphere) and living organisms (biosphere). The environment is the medium for plant growth and natural habitat for human. It is the source of water needed for biotic functions, especially the dissolution of minerals and some vitamins needed by the body for proper functioning. Air as a component of the environment is needed for respiratory activities and helps in oxidation of food and chemical substances in the body to release energy needed by the tissues and organs of the body.

Agricultural activities are supported by the soil which provides support to the plants and provides nutrients required by plants for optimum growth and yield. The soil flora and fauna, as major components of the environment help in the regulation and balance of the ecosystem. In order for the environment to perform its functions optimally, it must be properly managed because unguided exploitation of the environmental resources can cause its degradation. It is therefore pertinent to use the environment in a sustainable manner to get the best out of it.

What is Environmental Sustainability?

According to Caldwell (1998), World Commission on Environment defines a sustainable society as one that meets the needs of the present without compromising the ability of future generations to meet their own needs. Environmental sustainability therefore centers on using the environment to meet the needs of the present without jeopardizing the ability of the environment to meet the needs of future generations. Agricultural production depends largely on land, and the quantity and quality of produce from the land is affected by many variables, including the size of the land, soil fertility and extent of pollution of the environment. To sustain the environment, various policies and principles are put in place. These include forest resources protection, whereby individuals and cooperate bodies are prevented from illegal and uncontrolled felling of forest trees, hunting and other illegal forms of exploitation, afforestation aimed at planting trees or replacing any three that is cut down, prevention of bush fire, minimum tillage and crop rotation. Others, according to Okoro, Etuk and Akpan (2016) include application of organic fertilizer, contour cropping and Taunya farming. The environment should be used appropriately

bearing in mind the need to avert activities that may cause its degradation.

Environmental Degradation

Environmental degradation is the deterioration of the environment through depletion of resources which include all the biotic and abiotic elements that form our surrounding; the air, water, soil, plant, animals, and all other living and non-living elements of the environment (Maurya, Ali, Ahmad, Zhou, de Silva Castro, Khane and Ali, 2020). It covers many issues including pollution, biodiversity loss, animal extinction, deforestation and global warming. It is caused by natural and human activities. Natural causes of environmental degradation include flood, drought, climate change, etc. In the same vein, there are many human activities that cause environmental degradation. These include increase in human population, urbanization, bush clearing, burning and other agricultural activities. Pollution of the environment as a form of environmental degradation is caused by many factors. Among these factors are fumes from automobiles and industries, dumping of toxic substances into water bodies and improper disposal of both domestic and industrial wastes.

There are many ways in which environmental degradation can be controlled. It should however be noted that prevention of environmental degradation is better than controlling, because when the environment is degraded, remediation activities may require so much resources and may take a long time to return the environment to its original state. In some cases, it may rather be very difficult, if not impossible to revert the situation. Therefore, to control environmental degradation, many activities and actions should be minimized or prevented. These include minimizing the burning of bio-mass, ensuring proper sanitation at all levels, imbibing best-practices in agro-chemical handling and minimizing the use of chemicals for industrial and agricultural purposes (Ulucak, 2021).

Meaning of Agriculture

Agriculture is the science and practice of farming for the production of food for man and animal, and raw materials for industrial use. It involves the cultivation of the soil and rearing of animals. Agriculture is divided into two broad areas: Crop production and animal husbandry. Cultivation of crops involves many activities. These include land clearing, stumping, ploughing, harrowing, sowing and harvesting. Others are weeding, fertilizer application and application of other agro-chemicals.

There are also many activities in animal husbandry. These include construction of pens, stocking feed formulation and production, pest/disease prevention/control and maintenance of hygiene. All these activities impact significantly on the environment and farmer's health. Care must therefore be taken to abate the adverse effects of these practices on the environment and farmer's health.

Understanding Health

According to Hanna and Cousens (2001), WHO defines health as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity. It is a relative state in which one is able to function physically, mentally, socially and spiritually to express the full range of one's unique potentials within the environment in which one lives (Svalastog, Donev, Kristoffersen and Gajovic, 2017). Health is therefore a multi-dimensional construct which must be considered and interpreted as such. It encompasses the physical wellbeing and transcends the spiritual aspect of man. Besides, the individual must be mentally and socially sound to operate in the environment. Health could be said to be on a continuum which ranges from ill-health to optimum health. The farmer's position on the continuum determines how healthy the individual is and the extent to which the individual can handle the complex

relationships between agriculture and environment to enhance their sustainability.

The Farmers' Health

The world's population is growing at an exponential rate, far above the rate of food production. Therefore, a more technological driven agricultural production strategy can help to narrow the gap between population growth and food production. The effect of technological advancement on increased food production is achieved when the farmers adopt agricultural innovations in the various farming systems. But with sick farmers, the rate of adoption and utilization of these innovations may be slow.

A consideration of the factors of production shows that though land, capital, labour and entrepreneur are the factors of production, entrepreneur, which in this case, the farmer is the coordinator of other factors of production. As the coordinator, the farmer should be in good health condition to operate at optimum level. The health of the farmer therefore, is critical in the production of enough food materials to feed the teeming population. However, often times, the farmer is faced with many health challenges as a result of agricultural activities and environmental pollution. The control of agricultural activities can reduce environmental pollution and the reduction in environmental pollution can enhance farmer's health.

The web-like relationships, if properly coordinated and managed can increase agricultural production and improve the health of the farmer. It is worthy of note that the health of the farmer is an important factor of agricultural production. When the farmer is sick, the quality and quantity of farm labour is reduced, resources for farm work are diverted to settle hospital bills and plan/calendar of activities are distorted. The caregiver's time, energy and other contributions to agricultural production is diverted. Agricultural production and productivity are greatly reduced. It therefore implies that increased agricultural production and environmental sustainability is a function of the ability of the farmer to control and coordinate other factors of production in the farm.

Environment and Agriculture Linkages and their Outcome

Soil, one of the components of the environment is a medium for plant habitation. It provides support and nutrients needed for plant growth. The atmosphere is a source of air to the plants for respiration, while water bodies serve as sources of water to the plants for metabolic activities. The environment provides rain that cools the plants, enhances seed germination and growth. Nutrients are absorbed by the plants as dissolves substances in water. Turgidity of the plant cells and strength for the plant stems are enhanced by absorbed water from the environment. Soil and atmospheric microbes help in decomposition of dead plants and animals, thereby releasing nutrients required by plants for growth and development. During rock weathering, soil particles are formed, while a number of minerals needed by plants are released. This makes the soil fertile for agricultural production. Decomposing biotic components of the soil add to soil fertility. Leguminous plants fix atmospheric nitrogen directly into the soil, thereby making the soil fertile.

Agriculture also has positive effects on the environment. Genetic engineering in agriculture has brought about many species of animals and crop cultivars that naturally did not exist. Some are pest/disease resistant, while some are drought tolerant, which can thrive in regions originally very difficult to exist. According to Killebrew and Wolff (2010) and Carcia (2020), direct effects of agricultural intensification on the environment includes changes in land use pattern, reduction in soil fertility and decrease in biodiversity. Other negative effects of agriculture on the environment include increase rate of soil erosion due to deforestation and

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Also, some chemicals used in agricultural production are harsh on the living component of the environment. Continuous cropping reduces the fertility of the soil and sometimes affects the soil structure. There is overgrazing in some areas, while streams are polluted by domestic animals, especially those raised under intensive system of farming. However, the intensity of these effects differs from one geographic location to the other, the type of farming system, the timing of the various activities, land management practices and topographic conditions of the area (Rohila, Duhan, and Kumar, 2017).

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Though environment plays key roles in shaping farmers' health, it has some direct and indirect negative effects on the health of the farmer. Sometimes there is excessive heat, whereby the farmers are subjected to heat stress; there may be drought, making water insufficient for the farmer's use. Floods are also experienced by the farmer, with associated health challenges and economic losses. Air is often polluted with dust particles and sometimes laden with fumes which is dangerous to the health of the farmer. This may cause some health challenges which include respiratory tract infection, air-bone diseases and cardio-vascular diseases. Crops grown on toxic environment may have residues of the toxic materials when harvested. Poorly drained environment may serve as a breeding place for mosquito, which causes malaria. Water-borne diseases thrive as a result of drinking polluted water. Some biotic components of the environment e.g., microbes cause various types of diseases, subjecting the farmer to health challenges.

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There are many positive effects of agriculture on farmers' health. It is the source of good food materials for the farmer's healthy living. It also produces the fiber needed for making clothing, which protects the farmer from harsh weather conditions, insect's bites and attack by some other harmful organisms. Agriculture provides some of the materials used for the construction of shelter to protect the farmer. It is important to the health of the farmer as a source of medicinal plants for the treatment of some of the farmer's diseases. Agricultural plants, through the process of respiration helps to make oxygen available for human respiratory purpose.

Indirect effects of agriculture on the farmer's health are numerous, one leading to the other. The extent of agricultural production affects farmer's income and the scope of the farmer in making choice of what to eat, the quantity, how and when to eat. It also affects the type of housing, the facilities for comfort and relaxation, and plays important role in affordability of good drinking water. Acquisition of health-related services is also a function of the economic status of the farmer. All these are major determinants of the farmer's health status.

Some agricultural practices also impact negatively on the environment. They cause environmental degradation. According to Malik and Murya (2014) and Yadav, Kumar, Pham, Gupta, Rezania, Kamyab and Talaiekhozani (2019), pollution of the environment as a fallout of agricultural activities poses serious threat to the farmer's health and longevity. Environmental degradation leads to the proliferation of some diseases and health challenges. Example is the prevalence of mosquito in some irrigated areas. The mosquitoes cause malaria that affects the health of the farmer. Heavily polluted soils may lead to the production of poor quality or unwholesome food materials, which can lead to malnutrition or foodborne diseases. Other negative effects of agriculture on farmer's health are the introduction of farm hazards, accidents, bruises and other forms of injuries and zoonotic diseases Diet-related and foodborne diseases are also fallouts of the linkages between agriculture and farmers' health.

Desirable, but indirect effects of agriculture on farmer's health include increased crop yield as a result of fertilizer application, control of pests and diseases with the use of pesticides and prevention of weeds from competing with crops for nutrients through the use of herbicides. However, undesirable consequences of the use

of agro-chemicals according to Nicolopoulou-Stamati, Maipas, Kotampasi, Stamatis and Hens (2016), include an increase in the cost of agricultural production, presence of chemical residues in agricultural produce, and soil toxication, rendering some soils unfit for the production of wholesome agricultural products. All these are detrimental to the farmer's health. Agricultural product processing factories and automobiles emit greenhouse gases. Pungent smell from ill-treated animal droppings and dungs are also perceived, making the air unfit for healthy respiratory activities.

The Confluence

There are many strokes of indirect and direct interrelationships between environment, agriculture and farmer's health. These relationships result in both desirable and undesirable outcomes. Environment is degraded as a result of agricultural activities undertaken by the farmer. Components of the degraded environment including soil, water and air are sources of the farmer's ill-health, while the sick farmer is unable to increase the production of wholesome food materials needed for good health. However, sustainable environment enhances the production of good quality food materials necessary to maintain and improve the health of the farmer. A healthy farmer can operate efficiently, leading to increased agricultural production and efficient management of the environment.

Consequences of Uncoordinated Interactions

The uncoordinated relationships bring about undesirable outcomes or consequences. Among these is environmental degradation, where air, water and land are polluted (Woods, 2018), with reduced potential to support agricultural activities. In the process, plant products are tinted with chemical residue and unwholesomely unfit for human consumption. These agricultural products when eaten by human tend to result in foodborne or food-related illnesses. Direct influences of polluted environment on man are many. According to Kellebrew and Wolf (2010), the air is unfit for respiration; contaminated water bodies unfit for drinking, and heavily polluted or degraded soil unfit for the production of good food materials.

Poor health of the farmer or other consumers of agricultural products is another major undesirable outcome of the unguided linkages. Farmer's poor health condition affects many stages of the produce value chain. The quantity and quality of the produce are adversely affected. Agricultural production and productivity decreased and the keenness at producing quality food and industrial materials are also reduced. The environment is negatively affected as the farmer's strength for proper farm planning, implementation and coordination of the various farm activities are reduced. Appropriate and timely execution of activities in the farm for the maintenance of a balanced ecosystem may not be guaranteed. Daily plan of work and calendar of activities are distorted. Furthermore, the culminating effects of unregulated relationships of the trio is low yield of crops. This may also result in the production of low-quality agricultural products. Farm income is reduced, food security is threatened and the production of care-intensive agricultural crops and animals may be seriously affected. These may lead to poor nutritional status of the farmer, culminating in malnutrition and nutrient deficiency diseases.

Issues of Concern

Sustaining the environment, while increasing the production of wholesome food materials to enhance consumers' health is a problem that must be tackled holistically with multi-sectoral approach. Environmental policies must recognize and in cooperate effects of agricultural practices on the environment. This is with the aim of working with all the sectors to keep the environment healthy. Also, the interrelationship between agriculture and the environment need

be controlled and coordinated. Agricultural policies should be formulated and implemented with the health of the consumers and environmental sustainability as the focus. This should be done while not undermining increased agricultural production and productivity. The farmer, while producing to enhance good health of the consumers, should abhor activities that may degrade the environment. At this point, as observed by WHO (2015), policy makers in the three sectors should not work in isolation, but as a unit working towards achievement of a common goal – quality interconnectedness of the sectors.

Conclusion and Recommendations

The linkages among environment, agriculture and farmer's health result in both positive and negative outcomes. Though with some negative outcome, the interaction is inevitable and should be coordinated and managed to reduce the undesirable effects. In order for agricultural production to thrive and the environment sustained, while not undermining the health of the farmer, it is recommended that activities of the three sectors be coordinated by stakeholders in the sectors. Formulation of policies for the three sectors should not be done independently, but should be a joint activity. Execution of plans for the sectors should be jointly monitored and evaluation should be carried out jointly to identify and correct non-compliance. A periodical re-assessment of the policies should be done by policy formulators. Response team should be constituted and empowered to monitor, detect and respond appropriately to issues arising from the interactions among the three. A periodic meeting of stakeholders should also be undertaken.

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Vulnerability of the natural capital of tropical soils to tillage-induced degradation: A Review

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Abstract: *Soil tillage plays a major role in crop production by providing a homogenous seedbed to ease germination, crop establishment and growth. In tropical areas, with massive vegetation and plant root proliferation, tillage becomes very necessary to rid the soil of retardations caused by previous roots for the penetration of new roots. Irrespective of how important tillage may be, it interacts with the vagaries of weather and climate to exacerbate soil degradation in the tropics. This reduces the natural capital of the soil, thus the capacity of the soil to perform its ecosystem functions of regulating, supporting and provisioning. A healthy soil is able to provide these services while resisting degradative changes. Soil natural capital represents the arrangement of soil components in a manner that enhances the flow of benefits to man and the society. The concept seeks to attach value to the services provided by the soil, thus a move to unify soil and environmental scientists with economists. Tropical soils are old, fragile, lacking in inherent nutrients due to the nature of parent materials on which they are formed as well as extreme climatic conditions. The poor conditions of these soils are further worsened by the need for increased food production, which has over the years had put much pressure on land, resulting in unsustainable soil management, including frequent soil tillage. This is evidenced as loss of sequestered carbon to the atmosphere; impeded water infiltration and transmission, plants roots and microbial asphyxiation, reduced nutrient and plant water availability, increased runoff and erosion, reduced water quality owing to increased sediment load, etc., all of which limit the ability of the soil to perform its ecosystem functions nay cause decline in the soil natural capital. Embedding the natural principles of soils recovery and carbon accumulation into soil management practices has been identified as the most potent means of improving soil ecosystem services and increasing soil natural capital.*

Keywords: Soil natural capital, soil functions, tropical soils, tillage, soil degradation
CITATION:
Utin, U. E. (2023). Vulnerability of the Natural Capital of Tropical Soils to Tillage-Induced Degradation: A Review. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp.65-76

Introduction

Soil supports human life and promotes environmental health and sustainability through the ecological functions bequeathed to it by nature. How much the soil has fared in the performance of these functions is affected by

anthropogenic activities that lead to soil degradation (Begum, 2021; Nunes *et al*., 2020; Gomiero, 2016) and the loss of its natural capital (Ferreira *et al*., 2022). Soil natural capital is an emerging concept in environmental analysis and represents the collection and arrangement of mass and energy in the soil (Robinson *et al*., 2014), either naturally or by modification (Vereecken *et al*., 2016) in such a way that supports the flow of benefits to man and the society (Sá *et al*., 2022). The long history of land use for different purposes without commensurate efforts to replenish the lost resources had continuously exploited the soil of its natural capital, leading to the declining capacity of the soil to perform its ecological functions.

Compared to damaged soils, soils of a stable ecosystem are more structurally stable, fertile (Juo and Franzluebbers, 2003) and are characterized by improved water infiltration and water transmission (de Almeida *et al.,* 2018; Owuor *et al.,* 2016; Fueki *et al.,* 2012), which are the key factors that enhance groundwater recharge (Owuor *et al.,* 2016), reduces runoff, flooding and erosion (Liu *et al.,* 2019; Ontl and Schulte, 2012). The quality of water that flows through soil into groundwater and surface water bodies is also improved by the buffering and filtering capacities made possible by structural stability (Nelson and Su, 2010; Burauel and Bassmann, 2005; Aitken *et al.,* 1990). Microorganisms draw from an abundance of energy sources provided soil organic carbon (Franzluebbers, 2002) and take advantage of an improved balance of air to moisture in the dominant inter-aggregates pores for their metabolism (Franzluebbers, 2002; Aon *et al.,* 2001). Soil structural stability also helps to improve the quality of air if properly managed to sequester SOC and physically protect it from microbial decomposition. This can be achieved by adopting soil management options that reduce C emission to the atmosphere (Nivethadevi *et al.,* 2021; Liu *et al.,* 2019; Kumar *et al.,* 2013) as well as rid the air of dust and other contaminants emanating from the soil (Katra, 2020). Most soils of the tropics are lacking in inherent fertility and structural integrity (Igwe, 2011). The rate at which tropical soils are degraded is higher due to its nature, frequent land use transformations, soil management (Machado, *et al*., 2019; Tivet *et al*., 2013) and of course climate. The heavy rainfalls promote leaching and soil erosion of fine soil particles while the high temperatures cause excessive decomposition of soil organic carbon (SOC) (Igwe, 2011). Soil degradation due to tillage is assuming a big dimension globally. The purpose of tillage is to create conditions that aid the germination of seeds, crop establishment and growth (Singh *et al*., 2018). However, tillage of fragile and nutrient-poor soils, such as those of the tropics could trigger a high degree of soil degradation leading to further loss of soil natural capital, thereby undermining the ecological functions of the soil. Studies have reported the degradation of tropical soils as a result of tillage (Tivet *et al*., 2013; Igwe, 2011; Dieckow *et al*., 2009; Sá *et al*., 2001). In as much as the concept of soil natural capital is a growing one, there is paucity of research information on the effect of tillage-induced soil degradation on soil natural capital and ecosystem functions for most part of the tropics, especially the sub-Saharan Africa. This article is therefore aimed at highlighting the vulnerability of the natural capital of tropical soils to tillage-induced degradation.

Soil Ecosystem Services

The soil occupies a central position in the ecosystem and serves as a medium through which mass and energy are transmitted between other components of the ecosystem (atmosphere, hydrosphere, biosphere and the underlying lithosphere) (FAO, 2015) and through which benefits to humans are derived (Ferreira *et al*., 2022). In recognition of this important role of the soil, "soil ecosystem services" was conceptualized in 2005, which stipulates the

provisioning, supporting and regulatory functions of the soil (Baveye *et al*., 2016) as summarized below:

Provisioning services: The soil provides tangible products that are ultimately of benefit to man. These include food, fibre, clean water, drugs (Kanwar, 2018); habitat for plants, soil organisms and human beings; physical support for plants and structures like roads buildings, sporting facilities (Dominati *et al*., 2010).

Supporting services: The soil support processes that lead to water cycling, nutrient cycling, and the formation of new soils (Vereecken *et al*., 2016).

Regulating services: The soil is also involved in activities that regulate the environment to ensure that the natural ecosystem order is maintained by offering resilience to degradative processes that could be harmful to the environment (Dominati *et al*., 2010). Examples of regulating services of the soil include climate regulation, waste recycling, buffering and filtering (Vereecken *et al*., 2016).

Ecosystem services are maximized in the natural ecosystems whereas land use change and the concomitant disruption of the structural architecture of the soil often limit the capacity of the soil to perform its ecosystem functions (Or *et al*., 2021; Machado, *et al*., 2019).

Soil Natural Capital

The long history of usage of land in ways that are beneficial to man is well acknowledged. The physiocratic theory proposed in the 18th century by Quesnay underscores the role of land for agricultural production while classical economists, including Adam Smith and David Ricardo considered land (soil, water, air, minerals, soil organisms and climate) as factor of production and wealth creation for nations (Wikipedia, 2023).

The soil has long been exploited in rendering ecological services to man and the environment without adequate knowledge of how much it of it has been used up. The concept of natural capital is aimed at attaching financial meaning to non-financial information to make them appreciable to financial decision makers (NCC, 2018). The concept of soil natural capital considers the soil as the bank account, while soil exploitation for food production (and other activities) are viewed as withdrawals (Davies, 2018), which represents the debt to be paid back to the soil by providing conditions that will allow the soil to rejuvenate. Presently, there is a very huge and uncertain amount of carbon debt to be paid to the soil, accruing from several millennia of unsustainable land use (Sanderman *et al*., 2017). The concept of soil natural capital seeks to unify the roles of soil and environmental scientists with those of economists (Robinson *et al*., 2017; Hewitt *et al*., 2015). The benchmark natural capital is the state of soil natural capital at the beginning of land use project / soil management with which future changes in the soil natural capital can be compared (Ovando, 2021).

The Nature of tropical soils

Tropical soils are found between the Tropics of Cancer and Capricorn (Igwe, 2011). It includes the Equator and parts of Africa, South America, North America, Australia and Asia (Costa *et al*., 2022). The tropical climates are characterized by very high rainfall intensities and frequencies with mean rainfall amounts ranging from about 1000-1500 mm in the savanna regions, being the fringes of the tropics (Smith, 2022b) to over 1800 to 2,800 mm in the rainforests (Smith, 2022a). Soils of tropical latitudes have varying temperatures, though temperatures are generally high. Soils having mean annual temperatures (MAT) of 15–22 °C are classified as isothermic while MAT of 22 °C or higher are classified as isohyperthermic and those within the isomesic temperature regimes have soil temperatures less than 15 °C (Buol, 2013).

Tropical soils are mature and low in inherent fertility (Chesworth *et al*., 2008; Juo and Franzluebbers, 2003), except those formed on

alluvial volcanic parent material (Finkl, 1999). Soil orders identified in the tropics are Oxisols, Ultisols, Alfisols, Aridisol, Inceptisols, and Entisols (Igwe, 2011). The high rainfall and temperature of the tropics promotes almost complete weathering, which favours increased concentrations of sesquioxides (Chesworth *et al*., 2008), thus giving the tropical soils its bright colours.

The tropical climate support a wide diversity of plants and large carbon storage in plant biomass (Hofhansl *et al*., 2020; IPCC, 2000), thus giving rise to increased carbon storage in the soil (Chen *et al*., 2018), especially in the tropical forests. Half of the total amount of carbon in tropical forests is stored in biomass while the other half is sequestered in the soil (IPCC, 2000). The rate at which the high temperature can cause carbon losses in the tropical soil is controlled by soil texture and can be higher where the texture is predominantly sandy soils, with limited capacity for carbon storage and stabilization (Hartley *et al*., 2021).

Tropical soils are primarily composed of kaolinites, oxides and quartz, which are basically non-expanding, thus the reason for the higher stability potentials of tropical soils than temperate soils (Igwe, 2011). The soils are highly variable in texture, ranging from sand to very clayey (Lacerda *et al*., 2016). The textural pores of highly sandy soils can behave like macropores (Howell, 2013), which enhances rapid water and air movement through the soil while the capacity for water retention is low (Igwe, 2011).

Vulnerability of tropical soils to tillage-induced degradation

The soil as a medium for plant growth is tilled to create a homogeneous seedbed for plant growth and yield (Or *et al*., 2021; Bilandžija *et al*., 2016). Tillage is the most common form of soil management practice which decreases the natural capital of the soil (Sá *et al*., 2022) and has over the over the years, surreptitiously posed a serious harm to the environment (Pretty and Bharucha, 2014). The natural soil is characterized by good pore size distribution and structural stability, sufficient for a balanced ecosystem and the optimization of ecosystem services and the soil natural capital. Excessive tillage is therefore an aberration of the natural ecosystem order. The soil is degraded by tillage because soil structural pores are (formed by soil macro-aggregates) are weak and can easily be broken by tillage implements (Hallett, 1995). Soil structural degradation by tillage depends on the pore structure, hydromechanical properties of the soil, moisture content and the mechanical actions of the tillage implement (Hallett and Bengough, 2013).

Compared to temperate soils, tropical soils are more vulnerable to tillage-induced degradation due to the higher rainfall and temperatures of the tropical environment (Igwe, 2011). Some of the changes that occur in the soil following tillage, which reduce the soil natural capital are reviewed in this section vis-à-vis the peculiarity of the tropical soils.

Effect on aeration and microbial communities: One of the aims of tillage is to improve aeration and oxygen diffusion rates (Khan, 2008). However, conventional tillage pulverizes the soil excessively, creating an unstable seedbed (Ghezzehei and Or, 2000) and a large volume of ephemeral macropores, which causes unnecessary increase in the flow of air through the soil above a certain threshold. Tillage-induced aeration is highest immediately after tillage (Josa *et al.,* 2013) and decline over time (Khan, 2008) as the soil aggregates rearrange themselves with a flattening of their contact surfaces, in a bid to get stabilized after series of wet-dry cycles (Ghezzehei and Or, 2000; Or *et al.,* 2000) as well as and biological actions. This rearrangement is controlled by natural forces and seeks to return the soil to its natural (pre-tillage) state.

Soil aeration following tillage has been acknowledged to trigger the activities of microorganisms and increases the decomposition of SOC. This occurs first, due to the redistribution of SOC by tillage, which promotes access to organic substrates by microorganisms (Srour *et al*., 2020; Schmidt *et al*., 2018) and second, the increase in oxygen diffusion rate to aid aerobic microbial respiration, which evokes a fast-growing competition for the organic substrate among microbial communities and a flush of CO_2 into the atmosphere (Srour *et al*., 2020; Ben-Noah and Friedman, 2018). Aeration from frequent tillage of tropical soils with low annual carbon inputs can render the soil exhausted and increasingly infertile. Such soils experience accelerated microbial activities and carbon decomposition annually when plants get to senescence and shed their leaves, but as the substrates are being used up, microbial growth and activities consequently decline (Campbell *et al.,* 2022).

Increase in soil temperature: Soil temperature plays important roles in ecosystem processes, such as soil formation, plant growth and development, microbial activities, decomposition and mineralization of SOC, hydrologic cycle, etc. The natural arrangement of SOC in the soil helps to regulate soil temperature by its ability to increase soil porosity and reduce thermal conductivity (Zhu *et al.,* 2019). The specific heat capacity of soil particles is less than those of organic matter and water. A soil with a higher carbon saturation will hold more water and will heat up much slower than a new seedbed created by tillage, in which the surface carbon has been mixed within the soil profile. A study found increase in the temperature of tropical soil resulting from the disruption of the natural arrangement of organic matter and its incorporation in the soil by tillage (Furlani *et al*., 2008). Increase in temperature can enhance ecosystem processes that depend on higher temperatures but temperature increases above normal can be obtained in the tropics (Zhang *et al*., 2016) and are indicative of conditions that fall short of the nature of a healthy and productive ecosystem (O'Brien and Hatfield, 2020). Degradative changes can occur in the soil with serious implications on environmental quality due to incremental temperatures. Ben-Noah and Friedman (2018) reported a two-to three-fold increase in oxygen consumption and CO_2 production rates with a 10^oC increase in temperature. Undoubtedly, such increases account for the highest organic carbon degradation and CO_2 emission reported for tropical soils (Irina *et al*., 2019; Ross*,* 1993), which can increase the more when the soils are tilled.

Increase in organic matter decomposition and carbon emission: Carbon sequestered in the soil is a potential contributor to atmospheric carbon (Davidson, 2020). This is particularly evidenced in tropical forests, where soil degradation activities can increase the net carbon emission, more than annual inputs, such that the soils no longer act as carbon sinks (Dunne, 2017). Tillage erosion is an important means through which the soil is degraded (Öttl *et al*., 2021; Liu *et al*., 2020; Lobb, 2008). The increase in aeration that characterizes tillage causes a rapid decomposition of the disrupted carbon and their emission to the atmosphere as CO_2; this is more pronounced in the tropics because of the peculiar nature of the environment as explained earlier, and can proceed even faster due to tillage (Irina *et al*., 2019; Ross*,* 1993). Scientific experiments have affirmed the increase in carbon emission in soils following tillage (Valujeva *et al*., 2022; Zapata *et al*., 2021; Haddaway *et al*., 2017). Six *et al.* (2002) reported a 100% increase of organic matter decomposition in tropical soils over those of temperate regions.

Changes in water flow and retention characteristics: Water entry and drainage through the soil is controlled by the presence of interaggregate pores (macropores) while water

retention is made possible by intra-aggregate pores (micropores) (Menon *et al.,* 2020). On freshly tilled soils, water infiltration and drainage can increase significantly (Zhang *et al*., 2012), but the high intensity and amounts of tropical rainfalls can cause the breakdown of macropores (Igwe and Obalum, 2013), thereby increasing the volume of micropores. Wetting and drying cycles on tilled soils induce a swell-shrink condition that causes the coalescence of soil particles and aggregates, resulting in the slumping of the unstable seedbed (Ghezzehei and Or, 2000; Or *et al.,* 2000) and sometimes hard setting (Daniells, 2012). These alter the optimal capacity of the soil for water infiltration, transmission and retention, as well as groundwater recharge. The impact of tillage on hydrology can be worse in the tropical environment due to high amounts of rainfall and solar radiation to drive soil wetting and drying cycles.

Soil compaction: Apart from compaction that occurs in the subsoil due to aggregates coalescence, driven by wetting and drying cycles and subsequent hard setting (Ghezzehei and Or, 2000; Or *et al.,* 2000; Daniells, 2012), subsoil compaction is another degradative process that occur as a result of tillage. The propagation of stress to the subsoil can be linked a long history of conventional tillage has been identified as a factor for increased subsoil compaction (Seehusen *et al*, 2019). Soil compaction causes the constriction of pores; limits nutrient and plant water availability; reduces seed germination, crop emergence, root growth and overall plant growth and yield; reduces soil water infiltration and transmission; increases surface water ponding; overland flow and erosion, etc. (McKenzie, 2010). Soils can be more vulnerable to compaction as a result of high water content, low carbon contents (Gürsoy, 2021), which are typical of tropical soils.

Runoff, Flooding and Erosion: Tillage can increase the risk of runoff, erosion, and flooding. This can occur due to tillage-induced soil compaction. The reduction in soil volume and increase in bulk density which occur after series of wet-dry cycles on tilled soils and/or stress by agricultural implements can reduce the volume of macropores and limit the infiltration and drainage capacities of the soil (Gürsoy, 2021). When the rate of water application by rainfall or irrigation exceeds the infiltration capacity of the soil, any further water that arrives the soil goes into overland flow or runoff and pose erosion and flood risks. Due to the nature of tropical soils and the extreme climatic conditions they are severely affected by runoff, flooding and erosion (Eccles, 2019) and can get worse when the structure of the soil is disrupted by tillage.

Reduction in water and air qualities: The disruption of tropical soils with weak structure can further weaken the soil structure and increase the amount of soil particles and soluble nutrients that can easily be removed/detached and transported by runoff water into surface water bodies (USDA-NRSC, 2008; Le Bissonnais, 1996;). Turbidity of surface water bodies is indicative of the increased amounts of sediment load transported by runoff water. Similarly, soil structure disruptions have been observed to decrease air quality by increasing the amount dust particles in the atmosphere (Katra *et al*., 2020). Reduction in water and air qualities can be more obvious in the tropics due to the soil structural degradation, the increased runoff, higher temperatures and extreme droughts (Luo and Keenan, 2022).

Increased soil acidity: The increase in soil acidity of tropical soils is caused by the high rainfall, which increases the leaching of basic cations from the soil over time (Zhang, 2017). When the soils are tilled, the drainage capacity of the soil initially increases (Zhang *et al*., 2012) and may aggravate the leaching of cations from the soil. The rapid decomposition of carbon in tropical soils produces organic acids, with their H^+ ions replacing basic cations such as Ca^{2+}, K^+, Mg^{2+} on the exchange sites (Morris, 2004).

Sustainable soil management options

The only potent way of reversing the ecosystem to a pre-deterioration state is to allow nature to lead the way. The ecosystem has the natural ability to regulate, regenerate and sustain itself to maximize its ecological functions. Therefore, every soil management practice capable of rejuvenating and sustaining degraded soils must be congruent with natural principles of soil regeneration, key among which is the preservation of carbon in the soil. This informed the idea behind conservation agriculture, which is aimed at promoting minimum soil disturbance, maintenance of vegetative cover, planting of diverse plant species towards the enhancement of biodiversity/biological processes and the improvement of roots and above-ground biomass (FAO, 2022). With regards to this, tillage practices with respect to natural ecosystem preservation, often designated as 'no-till', zero-tillage, conservational tillage, have been adopted as a strategy to enhance sustained ecosystem services (Or *et al*., 2021; Busari *et al*., 2015; Pittelkow *et al*., 2015) and soil natural capital.

Conclusion

Soil disturbance by tillage can drastically change the ecosystem order and trigger soil degradation of monumental degree. The rate at which this can happen could be high in the tropics due to increasing severity of weather conditions occasioned by climate change. Degraded soils have limited capacities to perform soil ecosystem services, thus a reduction in their natural capital. The sequestration of carbon in the soil has been generally acknowledged as the natural mechanism that enhances the environmental health and stability. Carbon accumulation in the soil improves soil structure, aeration and support microbial communities; increase soil water infiltration, transmission and retention; improve groundwater recharge; provide good water and air qualities in the environment; support the growth and yield of crops; reduce carbon emission to the atmosphere; mitigate climate change. Managing the soil to preserve carbon is therefore the foundation for improving soil ecosystem services and preserving the soil natural capital.

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Pathogenicity And Management Of *Meloidogyne Incognita* On The Performance Of *Talinum Triangulare* In Uyo, Nigeria

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Abstract: *Studies were conducted to investigate the minimum population density of Meloidogyne incognita that can cause damage on Talinum triangulare in pot as well as evaluating nematicides on the growth and yield of T. triangulare grown in naturally M. incognita-infested field. Two-week old seedlings of T. triangulare stem cuttings grown in sterilized soil were inoculated with 0 (which served as control), 2,500, 5,000 and 10,000 eggs of M. incognita in pot while in the field, pre-plant treatment of T. triangulare with Nemguard® DE-nematicide, Mancozeb-fungicide, and 50% each of both pesticides) applied at 1 g/L/plot (2 m^2) as soil drench, equivalent to 5 kg/ha and the control. Data were collected on the vegetative growth and nematode reproduction in both pot and field trials. Results indicated that number of leaves, branches, plant height, leaf area and total shoot weight (yield) of uninoculated plants were significantly (P≤0.05) better than plants inoculated with various densities of M. incognita. inoculation at 2,500 and 10,000 eggs reduced T. triangulare yield by 45% and 52.9%, respectively in pot. While in the field study, nematicides applied at 5 kg/ha as soil drench significantly reduced nematode population in a naturally M. incognita-infested field and increased yield of T. triangulare by 29 - 42% at 11weeks after planting. Root rot was observed in plant inoculated with 2,500 eggs of M. incognita in pot and T. triangulare cultivated on M. incognita-infested field had severe root rot, and the nematode reproductive factor increased significantly in both pot and field. This study revealed that cultivation of T. triangulare on M. incognita-infested soil caused severe damage and yield reduction while pre-plant treatment of field with nematicide at 5 kg/ha could suppress M. incognita multiplication and induce yield increase of T. triangulare.*

Keywords: Galling, nematicide, phytoparasites, reproductive factor, waterleaf, yield

CITATION:

Akpheohai, L. I., Udom, G. N., Sylvester, J. U. and Ekanem, M. M. (2023). Pathogenicity and Management of *Meloidogyne incognita* on the Performance of *Talinum Triangulare* in Uyo, Nigeria. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 51-64

Introduction

Vegetables are one of the most important components of our daily diet as well as a high value cash crop for small and large growers alike. Between 1970 and 2019, vegetables production in Nigeria grew substantially from 3.04 million to 16.7 million tonnes annually (Ibeawuchi *et al*., 2015). Vegetables are widely distributed in Africa irrespective of their origin and could be exotic or indigenous. Indigenous plants are considered native to Africa while exotic species originated in other continents like Asia, South and Central America but have been integrated with traditional Africa food culture and agriculture (Laker, 2006). Some examples of exotic vegetables grown in Africa include; *Celosia argentea* (silver cock's comb) *Latuca sativa* (lettuce), *Lycopersicum esculentum* (tomatoes) *Capsicum spp* (pepper), *Cucumis sativus*

(cucumber), *Alium cepa* (onions), *Allium sativa* (garlic), *Beta vulgaris* (beet root), *Moringa oleifera* (moringa) while vegetables indigenous to Africa include; *Telfaria occidentalis* (pumpkin), *Vernonia amydalina* (bitterleaf) *Ocimum gratissimum* (African basil) *Tamarindus indica* (tamarind) *Momordica charanta* (bitter melon), *Talinum triangulare* (waterleaf) (Remison, 2005).

Waterleaf-*Talinum triangulare* (Jacq.) wild is a nonconventional vegetable crop of the Portulacea family which originated from tropical Africa and is widely distributed across West Africa, Asia and South America (Schippers, 2000). In the past decade the consumption of *T. triangulare* in Nigeria had been on the increase and currently is estimated to about 22 - 47.58 kg/person/year (Hart *et al*., 2005). *T. triangulare* is a highly valued product in Nigeria food markets, among the market women and housewives (Nya and Eka, 2007). Its high demand is attributed to its nutritional value which has been proven to be high in crude protein (22.1%), ash (33.98%) and crude fibre (11.12%). It has some medicinal values in humans and acts as green forage for rabbit feed management (Ekpenyong, 1986). *T. triangulare* is used as a softener when cooking fibrous vegetable such as *Afang - Gnetum africana, Atama - Heinsia crinata* and fluted pumpkin - *Telfairia occidentalis* (Ibeawuchi *et al.,* 2007). The leaves and young shoots are used to thicken sauce and it is consumed in large quantities in the Southern part of Nigeria. It is considered medicinal in Southern Nigeria as it is used as herb for measles and stomach upset (Udoh *et al*., 2005), and it performs well as fodder for raising giant snails (Ebenso and Okafor, 2002). Waterleaf as a vegetable has some inherent characteristics which makes it attractive. Firstly, it is a short duration crop which is due for harvest between 35- 45 days after planting (Rice *et al*., 1986), and it provides a complementary source of income to small scale farming households (Udoh, 2005). Secondly, they are not agronomically demanding and are suitable to many soil types. Their farming first started in 1983 when dry spell hits the country and there was dire scarcity of vegetables in the food market (Adebooye *et al*., 2003). By 2000, some farmers were doing so well enough to convince other farmers that they should convert to *T. triangulare* farming and the rate of conversions increased rapidly (Schippers 2000), these gave rise to the evolution of Fadama farming system. Now *T. triangulare* farming has been expanding rapidly in recent years, at an average of 10% of Nigeria's cultivable arable land area of about 71.2 m/ha (Opabode and Adebayo, 2005). The lucrative production of vegetables throughout the globe is threatened by large number of biotic factors including plant parasitic nematodes which affect plant growth and yield (Osei *et al*., 2011; Hussain *et al*., 2016). The root-knot nematodes are among the plant-parasitic nematodes belonging to the genus *Meloidogyne, M. incognita* (Kofoid and White, 1919, Chitwood, 1949) is probably the most economic important plant parasitic nematode species among the tropical and subtropical regions. Globally, the impact of *Meloidogyne spp*. is grossly underestimated causing an estimated yield loss of $157 billion annually on crops (Abad *et al*., 2008). According to Moens *et al*. (2009), *M. arenaria*, *M. incognita, M. javanica* (occurring in tropical regions) and M. *hapla* (occurring in temperate regions) are considered to be the four major *Meloidogyne spp*. Root-knot nematodes are the most frequently observed and damaging plant parasitic nematodes in vegetable production (Jones *et al*., 2013). In 2003, the host range already encompasses more than 3000 plant species (Abad *et al*., 2003). In Nigeria, root-knot nematodes can be found in all horticultural areas (Archidona-Yuste *et al*., 2018), causing yield losses in essential vegetable crops, such as cucumber (85%), tomato (59%), zucchini (40%), watermelon (36%) and lettuce 29% (Gullino *et al*., 2019). Phytoparasites that are responsible for 50% of banana losses. Coyne *et al*. (2006) also

found that 144% of galling on the yam tubers is as a result of *Meloidogyne spp* infection. The degree of damage depends upon the population density of the nematode, susceptibility of the crop, and environmental conditions such as soil fertility, moisture and presence of other pathogenic organisms, which may interact with nematodes (Evans *et al*., 1993). *Meloidogyne enterolobii* is an emerging threat considered as a very damaging pest because of its wide host range, high reproduction rate and the induction of more severe root galling than other root-knot nematode species (Castagnone-Sereno, 2012). For instance, yield losses of up to 50% and severe stunting of tomato rootstocks and cucumber were observed (Kiewnick *et al*., 2008). The presence of *Meloidogyne spp* populations puts agricultural production in Africa at a significant risk given the fact that most farmers do not have accurate information on the actual *Meloidogyne spp* present on their farms (Onkendi and Moleleki, 2013). When nematodes colonises the roots, they alter the uptake of water and nutrient and inhibit the translocation of minerals. Such alterations can affect the shoot-to-root (S/R) ratio, leading to poor plant growth (Gullino *et al*., 2019). Fawole *et al*. (1992) reported that 75% of Agricultural soils in Nigeria are dominated by different species of *Meloidogyne;* and they remain the most destructive group of nematode attacking field crops. Recent reports highlighted the prevalence of root-knot nematodes in *T. triangulare* cultivated areas in Cross River and Rivers State in the south-southern, Nigeria (Daniel *et al*., 2020, Tanimola *et al*., 2021). However, there is paucity of information on the pathogenicity of root-knot nematode, *M. incognita* as an important pest that causes yield losses of *T. triangulare* in Akwa Ibom State. Therefore, this study is set to investigate the pathogenicity of *M. incognita* on the growth and yield *T. triangulare* in pot as well as management of this nematode in field conditions, Uyo, Akwa Ibom State.

Materials and Methods

The experiment was conducted at Postgraduate Research Farm Town Campus, University of Uyo, and the Laboratory activities were carried out at Department of Crop Science Laboratory, Annex Campus, University of Uyo, Uyo.

Soil sterilization

A metal drum of 200 L capacity was filled half way with sandy-loam soil collected from the Botanical Garden, University of Uyo, Town Campus. The drum was placed on three big stones arranged in a triangular pattern. Water was added to moisten soil inside the drum and then covered with tarpaulin. Fire was then made with firewood arranged under the drum. A spade was used to stir the soil for even distribution of heat every thirty minutes. The steaming process continued for two hours at a temperature of 90^{o}C. The procedure was repeated until sufficient amount of sterilized soil was collected and packed inside 5 L pots and kept in the laboratory until needed.

Multiplication of *M. incognita* on field

Seeds of *Celosia argentea* were obtained from National Horticultural Research Institute (NIHORT), Idi Ishin, Ibadan. A nursery land area of 4 x 8 m was cleared, tilled to raise seedlings. Ten grams of Celosia *argentea* seeds was incorporated with 100 g of sand (i.e. 1: 10) mixed thoroughly then distributed evenly in the nursery then covered with mulch material to prevent loss of moisture from the nursery field. After two weeks, the germinated plant was transplanted at 50×50 cm planting distance on the field of 10 x 20 m where *T. triangulare* vegetables was grown previously and the plants were maintained for 10 weeks and kept weed free.

Extraction of *Melodogyne incognita* from galled root of *Celosia argentea*

After 10 weeks *M. incognita* eggs were extracted from galled roots of *Celosia argentea* using the sodium hypochlorite (NaOCl) extraction method described by Hussey and Baker (1973). The

galled roots were rinsed with water and then cut into small pieces of 2-3 cm and root pieces placed in a 2 L capacity conical flask, thereafter, 0.5% NaOCl solution prepared by adding 100 ml Jik + 600 ml of distilled water was poured into the root pieces and shaken vigorously for 4 minutes to dissolve the gelatinous egg masses to release the eggs. The dissolved eggs were emptied into nested sieves; 200 mesh sieve to retain the roots and the debris and 500 mesh sieve to retain the nematode eggs. The retained eggs were then washed into a beaker after several rinses to remove all traces of NaOCl. The number of eggs per ml of the suspension was estimated by counting under a stereomicroscope (Leica Wild M3C). This was then adjusted to 1000 eggs per ml by concentrating the suspension.

Pot experiment

The experiment was carried out in pot of (diameter=20 cm; depth = 25 cm) at the University of Uyo, Uyo, Akwa Ibom State (Lat. 5° 20´N and 5° 30´ N, Long. 7° 27´ E and 5´ 62 E at 68.0 m above sea level, average annual rainfall 2,500 mm, relative humidity 78%, monthly mean temperature range: 22-32°C.

Source of planting material

The stems of *T. triangulare* were obtained from the University of Uyo, Postgraduate Farm, Afaha Ube, Uyo. The stems of *T. triangulare* of 7 cm were planted in 5 L plastic pots containing steamed sterilized soil using a hand trowel. The stems were watered daily until leaf emergence.

After leaf emergence*, Talinum triangulare* in pots were treated with four *M. incognita* population densities; 0 which served as control, 2,500, 5,000 and 10,000 eggs, respectively. The experiment was laid out in a randomized complete block design with six replicates in and open field. The plants were maintained under adequate moisture, temperature, humidity and kept weed free.

Field experiment

Field studies was conducted to manage the damage caused by *M. incognita* with nematicides was conducted in the University of Uyo, Postgraduate Farm, Afaha Ube, Uyo. The experiment was laid out in a randomized complete block design in a *M. incognita*-infested field. Each block contained four treatments namely; control (*M. incognita*), 5 kg/ha of Mancozeb -manganese ethylenebis (dithiocarbamate), 5 kg/ha of NEMguard®DE (garlic derived nematicide), and combination of 50% each of Mancozeb and Nemguard®DE applied the at 5 kg/ha, replicated three times. Each block was subdivided into 4 plots (beds) of 1 m x 2 m, with a 0.5 m furrow to separate each block and plots. There were 12 plots in the field with a dimension of 5 m x 7 m =35 m^2. Subsequently, 1g/L/plot of each nematicide was applied as soil drench to each plot a week before planting *T. triangulare* except the control. Stems of *T. triangulare* cut 7 cm long with a sharp knife, were planted at 5 cm x 10 cm to achieve a plant population of 400 stands/plots equivalent to 2,000,000 stands/ha. The experiment was maintained, kept weed-free regularly and terminated at 11 weeks after planting.

Data collection

Harvest data on the vegetable was collected at 3 weeks after planting (WAP), 7 WAP and 11WAP respectively from randomly selected 20 tagged plants/plot. The harvest of vegetable was done by pruning with sharp knife at 7cm above the soil level and the fresh shoot harvested were weighed using ohasus weighing balance.

Data were also collected on number of leaves, number of branches, and plant height (cm) which was obtained by measuring the plant with a measuring tape from the base of soil to the tip of the longest leaf at inoculation, subsequently at 3, 7 and 11 WAP. The leaf area was determined by measuring the leaf from the base to its tip and the width from the widest point, using a ruler and multiplying the values

(Akonye and Nwauzoma, 2003) with a correction factor of 0.75 (Folorunsho *et al*., 2018). eleven weeks after planting, the experiment was terminated and plants were carefully uprooted and rinsed under running water to remove adhering soil. The whole root system was visually rated for galling on a 1-5 scale. where; 1= no galls, 2=1-15% of galled root, 3=16-30%, 4=31-60%, 5=61-100%, (Coyne *et al*., 2007). The eggs were extracted from 1 g of plant roots after chopping roots into 1-2 cm following the method described by Hussey and Barker (1973). The number of eggs from 1 g root per plant was counted and computed by multiplying with the total root weight per plant. Thoroughly mixed soil samples (200 cm^3) from each inoculated pots were collected and taken to the laboratory for the extraction of second-stage juvenile (J2) using modified Baermann pie-pan technique described by Coyne *et al*. (2007). The reproductive factor (RF) of the nematode was then calculated by dividing the final nematode population (Pf) by the initial nematode population density (Pi) (Windham and Williams, 1988).

In the field, number of harvested melons were counted and fruit weight (g) obtained, harvested roots from each subplot were rinsed, and rated for galls with the scale described above by Coyne *et al*. (2007). Thereafter, roots were chopped and prepared for nematode extraction as previously described. Soil of 1 kg was collected per plot and thoroughly mixed. Soil subsample of 200 cm^3 was taken for nematode extraction following Coyne *et al.* (2007).

The final nematode population in field was computed by summing estimated total number of nematodes per plant root and the total number of nematodes in soil per pot or 1 kg soil volume from each subplot in the field. The reproductive factor (RF) of the nematode was then calculated by dividing the final nematode population (Pf) by the initial nematode population density (Pi) taken from the field before the trial (Windham and Williams, 1988).

Results

Pot experiment

Effect of *Meloidogyne incognita* on number of leaves of *Talinum triangulare*

The number of leaves produced per plant in *M. incognita*-infested *T. triangulare* reduced significantly (P≤0.05) from week 7- 11 weeks after inoculation (WAI) than number of leaves produced in control (Figure 1). The highest number of leaves was produced at 11 weeks after inoculation in control with 150.33 leaves followed by plants inoculated with 2,500 eggs (114.50 leaves), 5,000 eggs (100.67 leaves) and 10,000 eggs produced 96.67 leaves. However, there was no significant difference (P≥0.05) between the control and inoculated plant with 2,500 eggs of *M. incognita (*Figure 1).

At 3 – 11 WAI, the control plants produced significantly (P≤0.05) taller plants (18.48 -19.42 cm) than plants inoculated with *M. incognita.* At 11 WAI*,* the height of inoculated plants was significantly shorter than the control (Figure 2) and the plants inoculated with 10,000 eggs had significantly (P≤0.05) shorter plants than the plants inoculated with 5,000 eggs at 11 WAI. However, there were no significant (P≥0.05) difference between the height of plants inoculated 2500, 5,000 and 10,000 eggs at 11 WAI (Figure 2).

The number of branches produced by plant in *M. incognita*-infested *T. triangulare* plant reduced significantly (P≤0.05) than the number of branches in control. The number of branches produced at 11 WAI in control plant was (11.83) followed by plant inoculated with 2,500 eggs which recoded (7.33 branches), while plants inoculated with 5,000 and 10,000 eggs produced 6.50 branches and 4.50 branches, respectively (Figure 3). However, there was no significant (P≥0.05) differences between 2,500 and 5,000 eggs of *M. incognita*-infected plants (Figure 3).

Leaf area (cm^2) produced per plant in *M. incognita*-infected *T. triangulare* reduced significantly (P≤0.05) than leaf area (cm^2) in

control. The leaf area produced at 11 WAI in control plant was 2.90 cm^2 followed by plant inoculated with 5,000 eggs which recorded 1.10 cm^2 while 2,500 and 10,000 eggs recorded 0.83 cm^2 and 0.61 cm^2, respectively. However, there was no significant (P≥0.05) difference between the branches produced by 2,500, 5,000 and 10,000 eggs of *M. incognita*-infected plants at 11 WAI (Figure 4).

The fresh shoot weight which is an indication of yield produced significantly (P≤0.05) heavier plants from 3-11 WAI in the control than the *M. incognita*-infected plants (Table 1). The cumulative yield produced per plant in *M. incognita*-infected *T. triangulare* reduced significantly than the cumulative yield obtained from nematode free plants. The total yield produced at 11 WAI in control plant was 46.55 g followed by plant inoculated with 2,500 and 5,000 eggs which produced 25.40 g and 10,000 eggs produced 23.88 g. However, there was no significant (P≥0,05) difference between cumulative weight of yield produced in plants infected with 2,500, 5,000 and 10,000 eggs of *M. incognita* (Table 1).

The root weight produced per plant in *M. incognita*-infected *T. triangulare* plant increased significantly (P≤0.05) than the root weight of control except in plants inoculated with 10,000 eggs (Table 2). The root weight produced at 11 WAI in control plants was 1.40 g followed by plants inoculated with 2,500 eggs (1.58 g) 5,000 eggs produced (2.05 g) and 10,000 eggs produced (1.00 g). However, there was no significant (P≥0.05) differences between root weight of control and plants infected with 2,500 and 10,000 eggs of *M. incognita*.

The galling index of inoculated *T. triangulare* was significantly (P≤0.05) higher than the control but not significantly different from one another, this ranged on a scale of 3.00 – 3.33 galls per plant at 11 WAI (Table 2).

The final nematode population in pot produced per plant in *M. incognita*-infected *T. triangulare* increased significantly (P≤0.05) than the final nematode in pot of control plant. Final nematodes in pot produced at 11 WAI in control was zero (0.00), followed by plant inoculated with 2,500 eggs (17,267.00), 5,000 eggs produced (17,830.00) and 10,000 eggs produced (21,1177.00). However, there was no significant differences in the final population of nematodes produced by *M. incognita*-infected plants (Table 2)

Also, the reproductive factor of inoculated *T. triangulare* was significantly (P≤0.05) higher than the control but not significantly different from one another, this ranged on a scale of 3.00 – 3.33 galls per plant at 11 WAI (Table 2).

Also, the reproductive factor (RF) of *M. incognita*-infected *T. triangulare* plants increased significantly (P≤0.05) than the reproductive factor in control at 11 WAI. The highest reproductive factor (6.91), this was significantly higher than the RF obtained from 5,000 and 10,000 eggs of *M. incognita* (Table 2). However, there was no significant differences between the RF of plants infected with 5,000 and 10,000 eggs of *M. incognita*.

Field study

Evaluating Mancozeb, Nemguard®DE and combination of both pesticides on the growth, yield and management of *M. incognita* on waterleaf

The pesticide treated plants produced more number of leaves than the control plants grown in the *M. incognita* naturally infested soil. However, there were no significant (P≥0.05) difference between the treated and the untreated soil (Table 3). The number of leaves produced by Mancozeb or/and Nemguard®DE treated plants ranged from 25.53 - 31.06 leaves while control was 22.12 leaves (Table 3). Similarly, the plant height followed similar trends as there were no significant differences between the control and the Mancozeb or/and Nemguard®DE treated plants (Table 3). The number of branches produced by the pesticide treated plants were significantly (P≤0.05) higher than the number of branches produced by the

plants grown in the control plots. Number of branches ranged from 5.53- 6.06 in the pesticide-treated waterleaf while the control had 3.40 branches (Table 3). Also, the leaf area of waterleaf was significantly higher in the pesticide-treated soil than the control. The leaf area ranged from 1.03-1.09 but not significantly different from one another in plants grown on nematicide-treated soil while the control was 0.61 (Table 3). Yield obtained from pesticide-treated plants increased significantly (P≤0.05) than those harvested from the control at 11 weeks after planting. Yield / ha ranged from 53,760.00 – 59,080.00 kg/ha in treated field while plants harvest from the *M. incognita* infested field was 41,360.00 kg/ha (Table 3). There were no significant (P≥0.05) differences between the fresh root weight recovered from nematicide-treated *T. triangulare* and the control (Table 4). Galling index, Final nematode population recovered from soil and root, and the reproductive factor was significantly (P≤0.05) higher in the control plots than in the nematicide-treated plots (Table 4). Galling index, final nematode population recovered and reproductive factor ranged from 2.71- 2.80; 9,870.33-11,029.00 and 0.65 – 0.73 in the nematicide-treated plots while the control was 5.00; 37,613.33 and 2.50 in that order at 11 weeks after planting (Table 4).

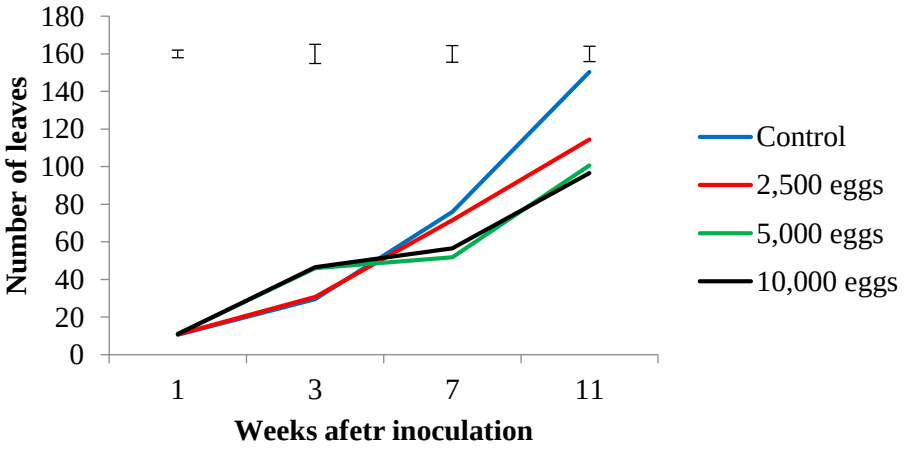

Fig. 1: Effect of *M. incognita* population densities on number of leaves of *Talinum* ***triangulare*** **11 weeks after inoculation in pot**

LSD bars are for comparing treatment means at each specific time

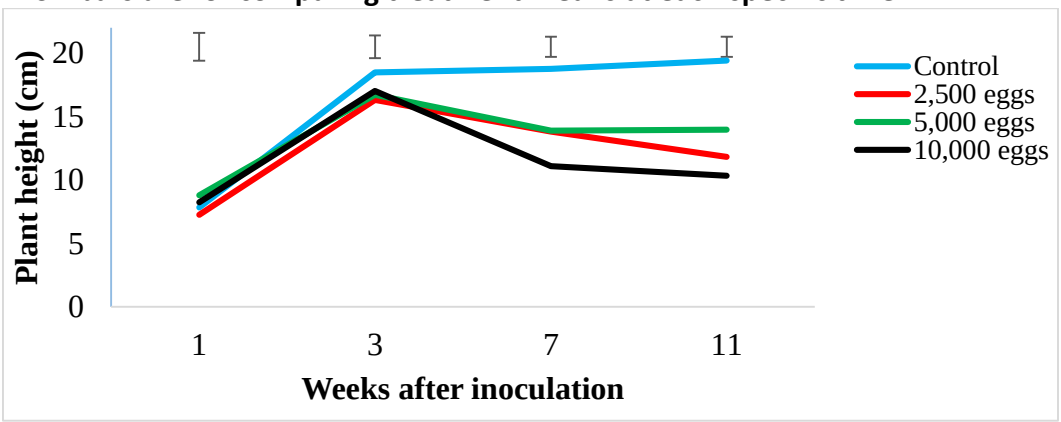

Fig. 2: Effect of *M. incognita* population densities on height of *Talinum triangulare* 11 weeks after inoculation in pot

LSD bars are for comparing treatment means at each specific time

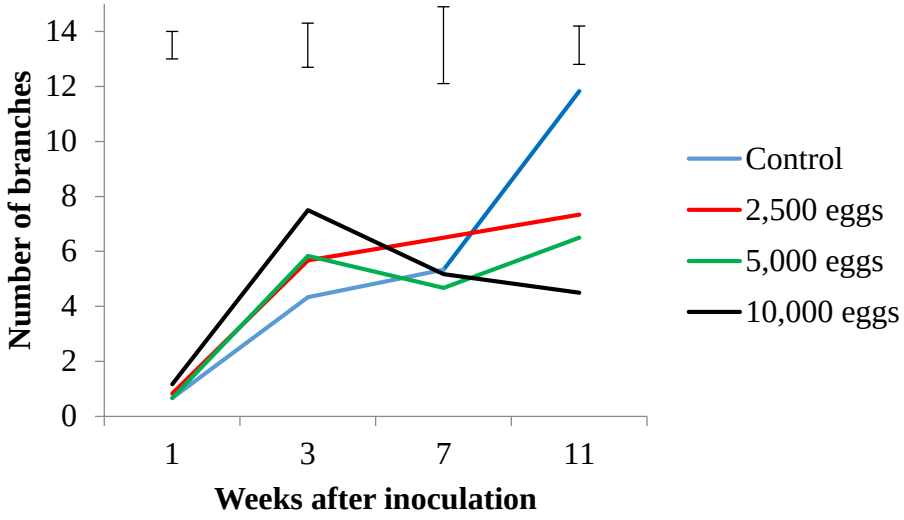

Fig. 2: Effect of *M. incognita* population densities on number of branches of *Talinum triangulare* 11 weeks after inoculation in pot.

LSD bars are for comparing treatment means at each specific time

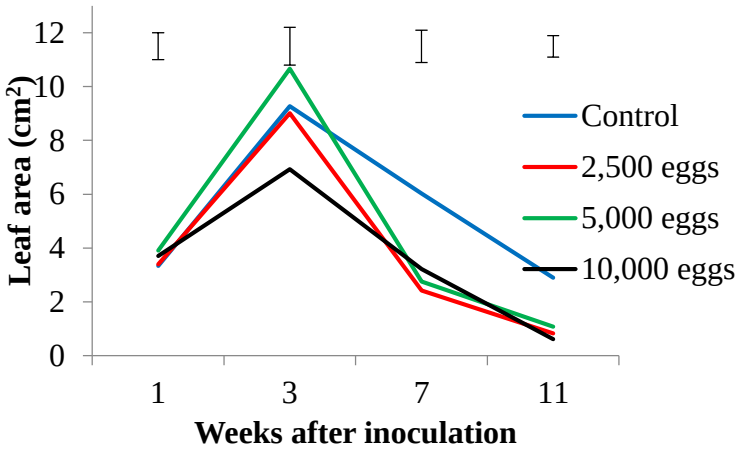

Fig. 4: Effect of *M. incognita* population densities on leaf area (cm²) of *Talinum triangulare* 11 weeks after inoculation in pot

LSD bars are for comparing treatment means at each specific time

Table 1: Effects of *Meloidogyne incognita* on fresh shoot weight (yield (g) of *Talinum triangulare* at harvest in pot, Uyo

	WEEKS OF HARVEST			
M. incognita eggs	3 (First harvest)	7 (Second harvest)	11 (Third harvest)	Cumulative yield /plant (g)
Control (0)	17.87	15.05	13.63	46.55
2500	6.87	6.25	12.28	25.40
5000	7.90	5.62	11.88	25.40
10,000	6.37	7.19	10.33	23.88
LSD (P≤0.05)	1.76	1.76	4.12	4.29

Table 2: Effects of *Meloidogyne incognita* population density on fresh root weight, galling index and nematode reproduction on *Talinum triangulare* in pot

M. incognita eggs	Fresh root weight (g)	Galling index	Final nematode population in pot (soil + root)	Reproductive factor (RF)
Control (0)	1.40	0.00	0.00	0.00
2,500	1.58	3.00	17,267.00	6.91
5,000	2.05	3.33	17,830.00	3.57
10,000	1.00	3.17	21,177.00	2.12
LSD (P≤0.05)	0.61	1.45	4,316.30	1.23

Table 3: Effects of nematicides on the growth and yield of *Talinum triangulare* and the management of *M. incognita* in a naturally infested field, Uyo

Treatments	Number of leaves	Plant height (cm)	Number of branches	Leaf area (cm^2)	Average yield /plant (g)	Average yield /plot (Kg/plot)	Average yield (Kg/ha)
Control (*M. incognita*)	22.12	11.80	3.40	0.61	20.68	8.27	41,360.00
Mancozeb (5 kg/ha) + *M. incognita*	25.80	12.26	5.93	1.03	29.54	11.82	59,080.00
Nemguard (5 kg/ha) + *M. incognita*	25.53	11.06	6.06	1.05	28.19	11.28	56,380.00
Mancozeb / Nemguard (5 kg/ha) + *M. incognita*	31.06	11.36	5.53	1.09	26.88	10.75	53,760.00
LSD (P≤0.05)	12.75	3.37	2.11	0.44	6.02	2.11	10,720

Table 4: Effect of nematicides on fresh root weight and the suppression of *M. incognita* reproduction in *Talinum triangulare* on a naturally infested field, Uyo

Treatments	Fresh root weight (g)	Galling index	Final nematode (soil + root)	Reproductive factor
M. incognita	5.12	5.00	37,613.33	2.50
Mancozeb (5 kg/ha) + *M. incognita*	4.39	2.80	9,968.66	0.66
Nemguard (5 kg/ha) + *M. incognita*	5.09	2.71	11,029.00	0.73
Mancozeb / Nemguard (5 kg/ha) + *M. incognita*	4.65	2.79	9,870.33	0.65
LSD (P≤0.05)	1.42 (NS)	1.15	7,678.15	0.51

Discussion

The current study revealed the damage caused as the population of *M. incognita* increased on *T. triangulare* and the activities of led to reduction in top growth, chlorotic leaves, smaller leaf area, reduced plant vigour, poor root growth and root systems of infested plant were galled. *M. incognita* inoculated at 2,500 eggs (i.e., 1 egg /2 ml soil) reduced *T. triangulare* yield by 45.5% while *T. triangulare* inoculated with 5,000 and 10,000 eggs (i.e., 2 eggs/1 ml soil) per plant reduced yield by 52.9% in pot. Severe root rot was also observed in plants inoculated with 10,000 eggs of *M. incognita* and sometimes eventual death of plants. This is consistent with Mukhtar *et al.,* (2017) observed that yield reduction of up to 34.1% was observed in okra inoculated with 3,000 second-stage juveniles of *Meloidogyne incognita* in pot. Also, Patel *et al*. (2020) observed that maximum reduction in potato cv. Lady Rosseta growth parameters inoculated with 10,000 J2 plant^{-1} pot^{-1}. Adegbite *et al.,* (2008) reported a yield loss of up to 48.7 in Roselle due to infestation by *M. incognita* in a field trial. Furthermore, there was increase in the population of *M. incognita* recovered from both root and soil of *T. triangulare* grown in pots regardless of the initial population density. This is in line with the report of Gergon *et al*. (2002) who reported the relationship between population density and pathogenicity of root-knot nematodes in vegetable crops by several workers such as Di Vito *et al.* (2004) on Yellow Granex Onion; Kumar and Pathak (2005) on Spinach; Vovlas *et al.* (2008) on Lettuce and Celery, and Parveen *et al*. (2006) on Japanese mint. The higher fresh root weight of infested plant might be due to abnormal secretion of growth hormones induced by root-knot nematode. These galls provide a nutrient sink to the nematode, resulting in higher root weight (Ogaraku, 2007). Reduction in plant height, number of leaves, leaf area, and number of branches which are the constituents of fresh shoot weight attributed to yield in *T. triangulare* were significantly reduced in pots inoculated with *M. incognita* regardless of population density.

In the field trial, the top growth of *T. triangulare* cultivated on the untreated *M. incognita*-infested field was severely reduced and by extension reducing yield/ha to 41,360.00 kg/ha. Conversely, pre-plant treatment of *M. incognita* infested field with synthetic fungicide Mancozeb 80WP or/and garlic formulated Nemguard®DE at 5 kg/ha applied as soil drench increased yield of *T. triangulare* by 29- 42% (i.e., 53,760.00 - 59,080.00 kg/ha). The protective efficacy of Mancozeb and Nemguard®DE against *M. incognita,* also enhancing the agronomic parameters have been demonstrated by Osei *et al.,* (2019) on yam and Eder *et al.,* (2021) on tomato. In addition, the decreasing top growth parameters recorded for the *M. incognita* infected *T. triangulare* plants was perhaps a result of the stunting action induced by the nematode in both pot and field. Furthermore, the reductions in *T. triangulare* yield parameters are due to root injury caused by nematode activities such as root penetration and the establishment of feeding sites known as giant cells by *M. incognita*, which resulted in a reduction in the efficiency of root systems to absorb water and nutrients from the soil. *Meloidogyne* spp. induce galls in the roots and large cells in the stellar region, which severely damage xylem tissues and significantly slow absorption and upward flow of water and nutrients. The infection also lowers the permeability of the roots to water. *Meloidogyne* spp. infection in root system triggers the formation of nurse cells and regulates increased transfer of photosynthates towards infected root tissue while other sections (foliage) suffer from a shortage (Wyss 2002; Di Vito *et al*. 2004; Mukhtar *et al*., 2017). Growth and development of leaf tissue and its constituents, particularly chlorophyll pigments, are hampered by an insufficient supply of water, nutrients, photosynthates, and energy (Khan and Khan

1997). Foliage growth is low, which results to diminished productivity in okra or cucumber (Hussain *et al*., 2016; Kayani *et al.,* 2017). The giant cells are highly specialized cellular adaptations required for parasitism which *Meloidogyne* females initiate and sustain in vulnerable plants (Castillo *et al*., 2001).

Infected *T. triangulare* infected with *M. incognita* produced higher gall index, final nematode population, and reproductive factor in both pot and field trials, implying that *M. incognita* reproduced and completed more than two cycles during the experiment. As a matter of fact, the longer the plant remained in the pot or field, the higher the population of *M. incognita* that would be deposited in the soil, which would be detrimental to subsequent cultivation of *T. triangulare* or any other crop the following season. This is consistent with the findings of Akpheokhai *et al*., (2012) on *M. incognita*-infected Soybean, Nwauzoma and Adeleke (2017) on *M. javanica*-infected Waterleaf, as well as Patel *et al*., (2020) on *M. incognita*-infected on potato cv. Lady Rosseta in pot trials.

During cropping of *T. triangulare* in the field trial, Mancozeb, Nemguard®DE, or a combination of both pesticides significantly decrease the galling index, final nematode population, and reproductive factor in the pre-plant treated plots than in *M. incognita* untreated plots. This suggests that the nematicidal action of Mancozeb and Nemguard®DE applied at the rate of 5 kg/ha as soil drench is more effective in inhibiting nematode entry into the root. As pesticides may act directly on the second-stage juvenile nematode in the soil, blocking or reducing egg hatching and larval migration into the root. This is consistent with the findings of Adegbite *et al*., (2008), Adegbite and Agbaje (2007), Akpheokhai *et al.,* (2012), and Eder *et al*., (2021).

In conclusion, the study demonstrates that a minimum population density of 2,500 eggs of *M. incognita* could induce damage on *T. triangulare* and consequently yield losses. In addition, the suppressive effects of Mancozeb-a fungicide, and Nemguard-a bionematicide, on root knot nematodes *Meloidogyne* species on *T. triangulare*, a vegetable that is well adapted to the stressful growing conditions of the tropics and has excellent nutritional qualities. Therefore, without a critical management plan in place to prevent *M. incognita* activities, a significant yield and revenue from the sale of this vegetable will be impossible in Uyo.

Acknowledgements

The corresponding author greatly acknowledged Dr Murree Groom, Technical Director, Ecospray UK for facilitating the provision of NEMguard®DE a formulated garlic nematicide required for this experiment**.** Also, Pathology Laboratory, Department of Crop Science, University of Uyo for providing facilities for this experiment. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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Effects Of Mornga-Cassava Based Intercropping Systems On Crop Yield And Organic Matter Distribution In The Humid Tropical Rainforest Agro-Ecology Of Southeast Nigeria

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Abstract: *The study was to investigate the effects of moringa/cassava based intercropping systems on crop yield and organic matter distribution in the humid rainforest agro-ecology of Southeast Nigeria in 2021 and 2022 cropping seasons. The experiment was laid out in a randomized complete block design (RCBD) in three replications. The treatments were Moringa, Cassava and Maize separately planted in their pure stands, moringa + cassava (Mo + Ca), moringa + maize (Mo + Ma) and moringa + cassava + maize (Mo + Ca + Ma) were simultaneously sown intercropped. Pre-planting from the sampling field and post-harvest soil samples from each treatment plot were obtained and analyzed in the laboratory for organic matter and organic carbon composition. The results obtained shows increased organic matter and organic carbon (4.05 and 3.83%) from pre-planting soil samples in 2022 cropping season. Results of post-planting of organic matter indicated an increased (5.88 and 5.93%) and organic carbon (3.36 and 3.57%) compositions in moringa + cassava + maize intercrop systems than in sole cropping in both 2021 and 2022 cropping seasons, respectively. Yield and yield components of crop were best when moringa and maize were planted sole while cassava grown in intercrop produced the highest yield. Moringa + Cassava crop mixtures produced the highest number of storage roots (18.14) and storage root yields (36.17t/ha). Maize yield was high in sole (2.34kg/ha) than in mixtures and moringa fresh leaf and dry leaf yields were observed to be high in sole (18.67t/ha and 3.33g) and (17.45t/ha and 3.43g) in 2021 and 2022 cropping seasons, respectively. The results shows that yield and yield components of crops were largely depended on the cropping systems. Appropriate cropping systems provide useful index in soil quality management and sustainable crop production,*

Keywords: Moringa, Cassava, Intercropping, Crop yield, Organic matter, Rainforest

CITATION:

Essien, B. A. (2023). Effects of Mornga Cassava Based Intercropping Systems on Crop Yield and Organic Matter Distribution in the Humid Tropical Rainforest Agro-Ecology of Southeast Nigeria. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 43-50

Introduction

Cassava and Maize are among the root and cereal component crops in the intercropping system, especially in Southeastern Nigeria. The practice of intercropping system is the commonest agro-technique by resource-poor farmers in many parts of the tropics. Intercropping therefore, is the simultaneous cultivation or growing of two or more crop species on the same field in the growing season (Law-Ogbomo and Ekunwe, 2011). This practice is carried out by the farmers in order to produce greater yield by making use of resources that would otherwise not be utilized by a single crop. Other advantages of intercropping are restriction

of spread of pests and diseases in epidemic proportions, generation of early monetary returns and year-round income and soil conservation (Udoh and Ndaeyo, 2000); as well as increased soil fertility if properly combined. Intercropping or crop mixtures mimic natural ecosystem and are dynamic biologically than sole crops (Law-Ogbomo and Ekunwe, 2011). Crop grown in mixtures are found to utilized resources better than sole crops (Chinaka and Obiefuna, 2000). The intensification of cropping, shorter fallow periods, erosion, flooding and leaching has cause decline in soil fertility status (Nottidge, 2005). This could be ameliorated by adopting a multi-cropping system that is sustainable and has some capacity to help in water infiltration (Bilalis *et al*, 2010); minimizes heat and water losses by evaporation, suppress weeds, recycle nutrients through litter falls and environmentally friendly.

Cassava (*Manihot esculenta* Crantz) is a very important food crop that is widely grown in mixtures especially amongst small scale farmers because of its productivity and compatibility as well as its capacity to withstand drought, provides energy carbohydrate in the storage roots and protein in the leaves. The storage roots, apart from providing dietary energy also provides essential raw materials for the industry and feed for animals (Samson *et al*, 2012).

Maize (*Zea mays* L.) on the other hand is a common staple food crop providing food for humans, feeds for livestock and raw materials for the industry (Onasanya *et al* 2009). It is the principal cereal crops associated with cassava in the humid tropics due to efficient utilization of resources. Cassava-maize intercrop are shown to be productive and compatible, mainly because maize is a short season crop while cassava is a long duration crop (Ikeorgu, 2002).

Moringa (*Moringa oleifera* Lam) popularly known as 'Eto uwem' in Ibibio (Essien *et al.,* 2015) is considered one of the World's most useful trees; as every part of the tree can be used for food or has some other beneficial property. It has the potential to improve nutrition, boost food security, foster rural development, use in medicinal purposes and support sustainable land use care (Essien *et al*, 2015). Moringa based intercropping system has been indicated to be productive and compatible because is a fast growing tree species with light canopy, soft and deciduous leaflets that detached easily, decompose and release nutrients to the under-storey crops (Essien *et al.*, 2015).

Intercropping could be seen as the practical application that ensures efficient use of resources and this can translate into maximum crop yield. Thus, proper understanding of a sound and sustainable intercropping system that integrates trees such as Moringa oleifera is very much fundamental to crop yield maximization. Moringa oleifera has the potential in nutrient supplementation through litter falls which are important factor in organic matter build-up in intercropping systems.

Soil organic matter (SOM) and soil organic carbon (SOC) are the most important indicator of soil quality and productivity (Brady and Weil, 2008). Soil organic matter is by-product of plants, animals and the remains of dead plants, animals and microorganisms. They play vital roles in the soil system including the physical, biological and chemical components of the soil (Brady and Weil, 2008). Maintaining organic matter in the soil at optimum levels is important for soil fertility and productivity. Therefore, to ensure sustainable crop production there is need to rebuild or rejuvenate soil health and quality through appropriate farming systems that are environmentally friendly, economically viable, sustainable and productive. Hence, this work was designed to investigate the effects of moringa/cassava based intercropping system on crop yield and organic matter distribution in Southeast Agro-ecology of Nigeria.

Materials and Methods

The study was conducted at family research farm in Itak Ikot Akpandem, Ikono Local Government

Area, Akwa Ibom State, Nigeria from 2021 and 2022 cropping seasons. The study site is geographically located between Latitude $5^{0}50^{1}$ and $8^{0}00^{1}$N and Longitude $5^{0}30^{1}$ and $7^{0}00^{1}$E (Udo *et al*, 2009), with altitude of 60m above sea level. The area is bounded on the North by Ndinya mfia, South by Iton Odoro/Mbio-Oku, West by Oduk/Iton Odoro and East by Nung Ukim communities. The area has annual rainfall range between 2000mm – 3000mm, characterized by two marked seasons, viz rainy season beginning from March to October (8 months) and dry season beginning from November to February (4 months). The area has high temperature range between 26^{0}C and 28^{0}C throughout the year. It has high relative humidity between 75% and 95% and this is same across other communities in the Local Government Area (AKS, 1989).The dominant vegetation is tropical rain forest which is tending towards secondary forest of predominantly wild palm trees, woody shrubs and various grasses growing underneath due to the activities of herdsmen (over-grazing) and bush burning. The soil of the area is acidic (7.76) and belongs to the broad soil classification group ultisol, formed from acid plain sand, low in organic matter, N, K and other nutrients (Brady and Weil, 2008).

The experiment was carried out on a land that had been left fallow for one cropping season, which was previously cultivated with cassava. . The site occupied area of 0.102ha and was cleared of any vegetation manually, marked into blocks and plots with plot size of 5mx4m and each block consisted of six plots. This was laid out in randomized complete block design (RCBD) with six treatments replicated three times. The treatment used were sole moringa (SMo), sole maize (SMa), sole cassava (SCa), moringa + cassava (Mo + Ca), moringa + maize (Mo + Ma) and moringa + cassava + maize (Mo + Ca + Ma).
After land clearing, pre-soil samples at 0 – 20cm depth were randomly taken at 4 points on the site and the samples were bulked together for analysis. However, post composite soil samples were also collected to determine the percentage of organic matter and organic carbon. The improved cassava cultivar used was TMS 30572 released by IITA, Ibadan, with moderate canopy spread obtained from the National Root Crop Research Institute, Umudike (NRCRI) and maize variety OBA super II, an early maturing hybrid maize cultivar that matures within 3 months; was collected from National seed council, Umudike. The moringa seeds were sourced (procured) from the Department of Forestry, Federal University of Technology, Owerri, Imo State.

Before planting, seed viability test on moringa and maize were carried out and these seeds were planted 3 per hole at a distance of 1m x 1m with a depth of 3cm at the base of the ridge. On emergence, the seedlings were thinned down to 1 plant per stand for moringa and 2 plants per stand for maize. The thinned down seedlings were used as mulch materials. Cassava stems were cut at 25cm long with at least 5 nodes and were planted at 1m x 1m on the crest of the ridge in an inclined position of about 45^{0}. At harvest, yield data collected were; number storage roots per plant (NOSR/P), number of marketable storage roots per plant (NOMSR/P), weight of marketable storage roots [WOMSR(kg/P)], Fresh weight of storage roots [FWOSR(t/ha)], number of cobs/plant (NOC/P), dry cob weight after shelling [DCWAS/P(g)], 1000 seed weight (g), and Grain yield [GY (kg/ha)]. All data collected were subjected to statistical analysis of variance (ANOVA) and means separated using least significant difference ($LSD_{0.05}$) as outlined by Akindele (2004).

Results

Effects of Moringa Intercropping system on the initial Organic matter (%) and Organic carbon (%) Composition at pre- planting

Results obtained (Table 1) shows organic matter and organic carbon composition of the study site before planting in 2021 and 2022 cropping seasons. The results showed that organic carbon and organic matter values were low (2.75 and

3.07%) in 2021 cropping season. However, there was an increase in organic carbon and organic matter (3.83 and 4.05%) of the study site in 2022 cropping season, respectively.

Effects of Moringa Intercropping systems on Soil Organic matter and Organic carbon (%) Composition on the study site at post- planting

Results obtained (Table 2) showed post-planting composition of organic matter and organic carbon as influenced by moringa intercropping systems. There was significant difference (P≥0.05) improvement on soil organic matter and organic carbon composition among the treatment used. The result shows that moringa crop combinations of Moringa + cassava + maize (Mo + Ca + Ma) produced the highest organic matter (5.88 and 5.93%) and organic carbon (3.36 and 5.57%), followed by Mo + Ca crop mixtures with 5.55 and 5.60% of organic matter and 3.30 and 3.45% of organic carbon; while sole cropping of maize produced the least organic matter (2.70 and 3.34%) and organic carbon (2.65 and 2.70%) in both 2021 and 2022 cropping seasons, respectively.

Table 1: Organic matter and Organic carbon (%) Composition of the Experimental Site before planting at 2021 and 2022 cropping seasons

Cropping year	organic matter (%)	organic carbon (%)
2021	3.07	2.75
2022	4.05	3.85

Table 2: Effects of Moringa – Cassava based Intercropping systems on organic (%) and organic carbon (%) composition during 2021 and 2022 cropping seasons after harvest

Treatment	organic matter (%)		organic carbon (%)	
	2021	2022	2021	2022
SMo	2.97	3.40	2.94	2.98
SCa	2.80	3.38	2.76	2.75
SMa	2.70	3.34	2.65	2.70
Mo + Ca	5.55	5.60	3.30	3.45
Mo + Ma	4.44	4.52	2.96	3.01
Mo + Ca + Ma	5.88	5.93	3.36	3.57
LSD (P≤0.05)	0.12	0.23	0.03	0.05

SMo = Sole moringa, SCa = sole cassava, SMa = sole maize, Mo + Ca = moringa + cassava, Mo + Ma = moringa + maize

Effects of Moringa Intercropping Systems on Yield and Yield Components of Cassava

The results (Table 3) indicated the effects of cropping systems on yield and yield components of cassava. The result shows that there was significant difference (P≥0.05) among the treatments used on cassava yield and yield components. The effects of cassava with moringa and maize intercrop on number of storage roots, non-marketable storage roots, marketable storage roots and fresh weight of storage root yields were observed in both sole and in crop mixtures at harvest. However, in 2021 and 2022 cropping seasons, cassava + moringa (Ca + Mo) crop mixtures produced the highest number of storage roots (18.14 and 22.33), and marketable storage roots (2.13 and 2.90); while cassava + moringa + maize (Ca + Mo + Ma) crop mixtures had the least number of storage roots (14.20 and 16.27) and marketable storage roots (2.04 and 2.32) in both 2021 and 2022 cropping seasons, respectively. Tuber or storage root yields recorded highest in Ca + Mo crop mixtures with 36.17 and 37.01t/ha while Ca

+ Mo + Ma crop mixtures produced the lowest storage root yields (28.33 and 30.22t/ha) in both 2021 and 2022 cropping seasons, respectively.

Effects of Moringa Intercropping Systems on Yield and Yield components of Maize

The results from the study (Table 4) shows the effects of moringa intercrop on maize yield and yield components in 2021 and 2022 cropping years. The result indicated that sole maize (SMa) cropping produced the highest number of cobs (22.00 and 23.75) and grain yields (2.34 and 2.45t/ha); while maize crop mixtures of moringa and cassava (Mo + Ca + Ma) produced the least number of cobs (19.00 and 20.00) and grain yields (2.10 and 2.09t/ha) in both cropping seasons, respectively. The results (Table 4) also showed that other yield components were higher in sole cropping than observed in crop mixtures.

Table 3: Cassava Yield and Yield Components as Influenced by Moringa-Cassava based Intercropping Systems at harvest during 2021 and 2022 cropping seasons

Treatment/Year	NSR/P	NMSR/P	WMSR (kg/P)	FWSR (t/ha)
2021				
SCa	16.33	12.67	2.08	33.17
Mo + Ca	18.14	14.02	2.13	36.17
Mo + Ca + Ma	14.20	10.53	2.04	28.33
LSD (P≤0.05)	2.03	0.11	0.03	0.55
2022				
SCa	18.00	16.45	2.58	33.54
Mo + Ca	22.33	18.07	2.90	37.01
Mo + Ca + Ma	16.27	14.02	2.32	30.22
LSD (P≤0.05)	0.04	0.65	0.02	0.68

NSR/P = number of storage roots per plant, NMSR/P = number of marketable storage per plant, WMSR = weight of marketable storage root, FWSR = fresh weight of storage root

Table 4: Maize Yield and Yield Components as Influenced by Moringa-Cassava based Intercropping Systems at harvest during 2021 and 2022 cropping seasons

Treatment/Year	NOC/P	FCW	DCWS/P (g)	CL (cm)	1000SW(g)	GY (kg/ha)
2021						
SMa	22.00	15.79	12.73	15.67	28.83	2.34
Mo + Ma	19.00	14.68	11.83	15.47	28.66	2.17
Mo + Ca + Ma	19.00	14.78	11.67	15.27	28.67	2.10
LSD (P≤0.05)	ns	ns	ns	ns	ns	0.01
2022						
SMa	23.75	16.82	14.33	15.70	28.95	2.45
Mo + Ma	20.25	16.79	14.03	15.55	28.70	2.20
Mo + Ca + Ma	20.00	15.55	12.73	15.20	28.55	2.09
LSD (P≤0.05)	ns	0.22	0.31	ns	ns	0.55

NOC/P = number of cob/plant, FCW = fresh cob weight, DCWS/P = dry cob weight after shelling/plant, CL = cob length, 1000SW = one thousand seeds weight, GY = grain yield, ns = not significant

Effects of Moringa Intercropping Systems on Yield and Yield Components of Maoringa oleifera

Yield and Yield components of moringa oleifera were significantly different (P≥0.05) among the treatments (Table 5). However, sole moringa (SMo) cropping produced the highest number of pods (20.33 and 23.81), length of pod (35.57 and 36.18cm) as well as number of seeds (15.30 and 15.90) in both 2021 and 2022 cropping seasons, respectively. Moringa + cassava + maize (Mo + Ca + Ma) crop mixtures produced the least length of

pod (31.92 and 32.19cm) and number of seeds (14.30 and 14.78) in 2021 and 2022 cropping seasons, respectively. Results obtained (Table 5) also revealed that sole moringa (SMo) produced the highest fresh leaf yield (18.67 and 17.45t/ha) and dry leaf yield (3.33 and 3.43g), while Mo + Ca + Ma crop mixtures produced the least fresh leaf yield (16.09 and 16.34t/ha) and dry leaf yield (2.16 and 2.53g) in both 2021 and 2022 cropping seasons, respectively.

Table 5: Moringa Yield and Yield Components as Influenced by Moringa-Cassava based Intercropping Systems at harvest during 2021 and 2022 cropping seasons

Treatment/Year	NOP/P	LOP/P (cm)	NOS/P	FLY (t/ha)	DLY (g)
2021					
SMo	20.33	35.57	15.30	18.67	3.33
Mo + Ca	16.67	33.60	14.31	16.33	2.63
Mo + Ma	16.00	35.13	15.40	17.85	3.07
Mo + Ca + Ma	16.59	31.92	14.30	16.09	2.16
LSD (P≤0.05)	0.58	2.31	0.40	0.78	0.06
2022					
SMo	23.31	36.18	15.90	17.45	3.43
Mo + Ca	15.69	32.60	14.83	16.05	2.85
Mo + Ma	18.20	35.70	15.58	17.03	3.01
Mo + Ca + Ma	14.90	32.19	14.78	16.34	2.53
LSD (P≤0.05)	2.03	5.60	0.53	0.06	0.03

NOP/P = number of pod per plant, LOP/P = length of pod, NOS/P = number of seeds per plant, FLY = fresh leaf yield, DLY = dry leaf yield

Discussion

The increase of the organic matter and organic carbon composition of the site before planting (Table 1) in 2021 and 2022 cropping seasons could have been attributed to previous cropping systems and climatic variables that might have been responsible for the increased result. This disagrees with the work of Osodeke and Ubah (2005), who had have previously reported low organic matter in acid soils of southeastern Nigeria. However, the increase in organic carbon and organic matter (3.83 and 4.05%) in 2022 cropping season could have been attributed to the decomposition of plant from previous vegetation crop in the field.

The significant (P≤0.05) improvement (Table 2) on soil organic matter and organic carbon could possibly attributed to litter falls from moringa oleifera inclusion in the system. This indicated that moringa has the potentials of enhancing soil fertility status. This agrees with the work of Azu *et al*, (2020) and Essien *et al*, (2015), who jointly stated that moringa inclusion in cropping system increased soil fertility through leaf decomposition leading to increased crop yield.

The effects of intercropping system on yield and yield components of cassava (Table 3) indicated that yield and yield components were largely depended on the cropping systems. However, the increase in the number of storage roots in cassava + moringa (Mo + Ca) crop mixture could be attributed to better use of resources for tuberization in the system. This disagree with the work of IITA (1986), who reported that cassava grown sole produced more and bigger storage roots than when intercropped with groundnut; indicating resource competition between cassava and groundnut at the early stages of growth. The yield attributes of cassava observed were significantly greater when cassava was planted in mixtures. This was probably due to the specie temporal complementarities in the system; due to decomposition of moringa leaves and other residues for cassava utilization resulting in greater yield. This is in line with

findings of Adipela *et al*., (2002) in cowpea/maize intercropping system, who reported that optimum growth and yield were achieved when component crops in the mixture were sown simultaneously.

Intercropping systems on yield and yield components on maize in 2021 and 2022 cropping seasons were observed highest when planted sole than intercrop (Table 4) probably due to better use of growth resources by the maize in sole cropping. This agrees with the work of Oyeogbe *et al.,* (2020), who stated that higher grain yields achieved in the maize sole cropping than those of the intercrops is a function of the growth resources including space, light, nutrients and moisture available to maize sown as sole cropping than when intercropped with cowpea, groundnut, and sweet potato. The reduction in yield and yield components of maize in maize mixtures could be due to plant – to – plant competition for resources. It seems that when the number of plant that gives optimum leaf area index (LAI) is exceeded, yield automatically drops because of excessive self-shading leading to reduction in net assimilation rate (NAR). This agrees with the work of IITA (1986) on cassava/groundnut intercrop, who reported that higher population in plant irrespective of cassava planting pattern, reduces net assimilation rate.

The effects of intercropping systems on yield and yield components of Moringa oleifera were observed to be better in sole than intercrop (Table 5) in 2021 and 2022 cropping seasons. This could be attributed to better use of growth resources during the growth periods indicating zero competition amongst other crops and the plant adaptability to the environment. This agrees with the work of Anyaegbu *et al* (2009), who reported that when resources are limited in an intercrop system, one species of the mixture may be able to remove the needed resources sooner or later than the other, indicating the depression in yield of the other crop species caused by competition. However, the increases in yield and yield components in moringa could also be attributed to the differences in the type of plant species and its adaptation to the environment. Moreover, the significant (P≤0.05) difference in Mo + Ma crop mixture than in Mo + Ca crop mixture could be as a result of crop species compatibility and the ability of the crop in mixture to cover their canopy thereby conserving soil moisture for growth and yield. This agrees with the work of Ogindo and Walker (2005), who stated that maize-bean intercrop has the potential to hold water due to high leaf area and leaf area index.

Conclusion

The result of this study have shown clearly the beneficial effect of moringa based intercropping system on organic matter and organic carbon content improvement of the soil. The maize grain yield and moringa leaf yield were higher at sole cropping while cassava storage roots yield was higher in crop mixtures. It can be concluded that it is advantageous to intercrop moringa, cassava and maize where the level of complementarities between the crop species will be high. The intercropped crops can be advocated as a promising production system and therefore recommended for farmers to effectively enhance land use and higher yield in the cropping system in the humid rainforest agro-ecology.

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A Review Of Information And Communication Technology In Agricultural Extension Services Delivery In Nigeria

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Abstract: *This paper reviewed on Information and Communication Technology (ICT) in agricultural extension delivery in Nigeria. Agriculture is also the major driver of the non-oil sector of the economy and is reputed as the most important and resilient sector in the Nigerian economy. However, agriculture with its positive impact on the nation populace, in recent years experienced slow agricultural development. The decline could be attributed to the inability of farmers to access vital information or poor dissemination of agricultural information. In addressing these challenges, appropriateness of ICT in agricultural extension services is a critical factor needed to stimulate the right knowledge and attitude of farmers towards agriculture production.*

Keywords: factor needed to stimulate the right knowledge and attitude of farmers towards

CITATION:

Nkeme, K. K. (2023). A Review of Information and Communication Technology in Agricultural Extension Services Delivery in Nigeria. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp.36-42

Introduction

Agriculture is the mainstay of the Nigerian economy and occupies a pivotal role in the development of the nation. It also remains an important sector due to its central role in reducing inequalities by increasing incomes and employment opportunities for the poor, while nurturing natural resources. Akpabio (2019) asserted that it employs approximately 65%-75% of the country total labour force, provides a means of livelihood for about 90% of the rural population and contribute to Nigeria's gross domestic product (GDP). Akpabio *et al.*, (2018). and Akpabio *et. al.* (2020) opined that agriculture is also the major driver of the non-oil sector of the economy and is reputed as the most important and resilient sector in the Nigerian economy. However, agriculture with its positive impact on the nation populace, in recent years experienced slow agricultural development. The decline could be attributed to the inability of farmers to access vital information or poor dissemination with no adequate feedback. In addressing the challenges that limit agricultural production, Akpabio *et. al*. (2018) reported that the underlying factor is related to information and knowledge; also poor utilization of technologies. Instant dissemination of relevant and reliable agricultural information remains the biggest challenge confronting agricultural development experts in developing countries. The decision on most farm operations or activities is a function of knowledge and information exchange between and among agricultural extension stakeholders.

Olatinwo *et al*. (2022) emphasized that access to information is one of the most vital ingredients in agricultural development. Odoemelam and Alocha (2015), opined that appropriateness of information is a critical factor needed to stimulate the right knowledge and attitude of farmers towards agriculture production. Achieving rural and agricultural development is a function of disseminating information, transfer of knowledge generated by agricultural research and encouragement of farmers to try out new discoveries (Unamma, 2011); thus, producing knowledgeable and well informed farming communities

Okorie *et. al*. (2018) submit that ICTs may be one of the ways in which farmers can access a variety of information sources that are accessible, affordable, relevant and reliable. Information on agricultural technologies developed in research institutes take a long time to pass through information processing and disseminating system. ICT (Information communication technology) help to provide knowledge to the door step of farmers, can enhance the integration and efficiency of agricultural systems by opening new communication pathway, given greater accessibility of information on weather/climate information, online land registration, fertilizers application, pest management and price output in the markets, production and post- production technologies.

The pace at which ICT application is growing in every sector of human endeavour is one of the answers to the threat on agricultural extension services effectiveness. ICTs have the potentials to really transform agricultural extension in developing countries like Nigeria. Unamma (2011) listed the potential applications of ICTs in agricultural extension to include:

a. affordable, reliable, relevant and location-specific information to farmers,
b. for networking among and between the key stakeholders in the Research-Extension-Farmers-Inputs-Linkage System (REFILS),
c. fast and prompt response to farmers' information needs,
d. Capacity to reach a large audience,
e. Extension workers will be globally connected and have up-to-date information,
f. the extension systems and structures become more efficient through better management of information and scarce resources,
g. searching and packaging of information on demand and for exploring of alternative production options and technologies,
h. can be effectively used for community mobilization, learning and action,
i. farmers will be connected directly by-passing extension workers and
ii. help extension workers develop new skills, and feedback between extension and clientele will greatly improve.

With the urgent need for current agricultural knowledge and information system (AKIS) by farmers the use of conventional communication channels such as farm/home visit, personal letters, and use of contact farmers, for disseminating agricultural information is ineffective. Thus, most extension information have been found to be out-dated, irrelevant and not applicable to small farmers' needs, leaving such farmers with little or no useful information to improve their productivity. ICT can also increase smallholder' access to timely extension information, reduce cost of extension visits, enable more frequent two-way communication between farmers and agents, improve agents' accountability, facilitate learning from one's peers through social media networks and improve flow of relevant information between farmers', agents and researchers.

ICTs sources of the Agricultural Information

Information and Communication Technologies are those technologies that are currently in use to interlink information technology devices such as personal computer with communication like telephones and their telecommunication networks. Unamma (2011) stated that the personal computer (PC) laptop with e-mail and internet provide the best examples. ICTs can give a new impetus to the productive activity of agriculture, which could become a major factor in the transformation stages of the Nigeria agriculture. In agriculture, easier and faster access to up-to-date market and price information assists farmers and rural based traders in their business. According to Unamma *et. al.* (2004) and Olaniyi, (2014)., modern ICTs provide remarkably powerful and cheap alternative means of dissemination of information. ICTs also provide real time updates on market information giving farmers more bargaining power on product prices and adjustments of production plans according to market needs. Agbamu (2013), observed that, ICTs increase interaction among the actors in agriculture as they facilitate collaboration and knowledge exchange nationally, regionally and globally. At the local level, they connect rural people to sources of information. In this way, they empower individual, groups and communities to effectively access, share and use agricultural knowledge. ICTs can enhance the integration and efficiency of agricultural systems by operating new communication pathways and reducing transaction cost by enhancing accessibility of information on price, transportation and production technologies (CTA, 2003 and International Institute for Communication and Development (IICD), 2017). ICTs in agriculture have the potential to facilitate greater access to information that drive or support knowledge sharing.

Information and Communities Technologies Tools in Agricultural Services Delivery:

Ozor and Madukwe (2015) explained that ICTs tool in agriculture are broadly classified into hardware (low) and software (high) equipment and machines, such as projectors, copying machines, telephones, radio and television sets are examples of low ICT (hardware) while the high ICT consist of various means of obtaining and transferring information using completers, telecommunication and microelectronics. Other ICT tools include cameras, video, email diskette flash drive, scanner, printer, internet, uninterrupted power supply, voltage stabilizer posters, magazine, newspaper leaflet, CD ROM, Digital Video Disk **(**DVD) etc. ICT consist of three main technologies namely computer technology, communication technology and information management technology. The tools provided by ICT are able are to: (a) record text, drawing, photographs, audio, videos, process description and other information in digital formats; (b) achieve greater interactivity in communicating, evaluating producing and sharing useful information and knowledge; (c) transfer information and knowledge rapidly over large distance through communication networks; (d) Produce exact duplicate of such information at significantly low cost and (e) developed standardized algorithms to equalities of information relatively.

Accessibility to Information Communication Technology

Access to ICT implies access to channels and modes of communication that are not bound by language, culture or distance. It also implies not only the physical availability to these models and channels but also the existence of the right conditions for their use in getting information. These conditions included the use of or user friendliness of the technologies, regular electric power supply and availability of spare parts. Access to knowledge and information in many

forms has become a key element of agricultural competitiveness at household regional and international levels. The transformation of agriculture in developed countries has taken place in a context of high literacy rates, well-functioning telecommunication systems, readily available electricity, an established and regulated credit and banking systems, well-developed transportation networks, high labor costs relative to the cost of computing equipment and reasonable easy access to ICTs (Chadwick, 2006 and Ugboma, 2012). In Nigeria, the government have encouraged private sector participation and attraction of foreign investment which consequently reduces the price of computers and other ICT equipment, making them more accessible.

ICT use in Agricultural Extension

Information and communication technologies (ICT) is the scientific, technological and engineering disciplines and the management technologies used in the handling of information, processing and application related to computers. ICTs have a possibility of strengthening the weak linkage between the tripartite parties: extension, research and farmers (Unamma *et al.,* 2004). Use of ICT involves the extent to which information technology devices are utilized for communication purposes and explains the level of which the potentialities of the technologies are harnessed for information generation and transfer. ICT capabilities consist of the resources needed to generate and manage information exchange, institutional structures and resources and linkages. It has also been noted that there is a penetration by and adoption of a wide range of computers and telecommunication usage capabilities in the developing countries. The number of ICTs use tend to increase over times as more users become familiar with the technology and as new ICT-based services or content become available.

Extension services globally involve dissemination of knowledge, agricultural information, and new technologies to farmers and rural dwellers. According to the International Food Policy Research Institute (IFPRI), agricultural extension (also known as agricultural advisory services) plays a crucial role in promoting productivity, increasing food security, improving rural livelihoods, and promoting agriculture as a pro-poor economic growth engine (IFPRI, 2020). The extension services introduce new ideas and technologies to rural inhabitants by using different approaches and methods. The main reason for using these approaches is to help farmers understand the information presented to them by the agricultural extension officers; in so doing, they may adopt the new technologies to improve their livelihoods and make them resilient to challenges facing their farming activities. Unamma (2011) and Umoren (2010) emphasised that, agricultural extension and advisory services can be a powerful tool to help smallholders break the cycle of low productivity, vulnerability, and poverty. By online dissemination and sharing of knowledge among experts, farmers, students and research scholars can encourage rapid adoption of efficient and modern farm practices. Some enterprises have developed virtual platforms to disseminate expert advice and technical knowledge, cutting across geographies and time zones to reach a potentially large audience.

Other enterprises have leveraged the prevalence of mobile phones to share information, and have set up call centres and help lines that farmers can access for answers to specific queries. He also reported that yet other solutions involve the inventive use of videos and design thinking to develop content and material that are easy to understand and internalize. Extension-based Farmers Helpline operated by Unified Agricultural Extension Service UAES Call is a call centre service staffed by agricultural experts that provide information, advice and support to

smallholder farmers over phone, providing voice and voice call-back facilities. By applying design thinking to extension services, extension-based Agro-Insight works closely with rural communities, using effective video and print materials. It designs and organizes tailor-made training courses for extension service providers as well as in the development of video and fact sheets for farmers. The extension also offers courses in surveillance of plant pests and diseases.

. It also offers a fully-integrated mobility solution that has a knowledge bank for farmers who can educate themselves on input dosage, usage and risk management. ICT enabled enterprises can also utilize their virtual platforms to provide farmers access to networks of experts.

ICT and Rural Development

Information and communication technology have become an increasingly powerful tool for improving the delivery of basic services and enhancing agricultural development opportunities. Today, a new paradigm of agricultural development is fast emerging in both developing and developed countries. The overall development of rural areas is expanding in new directions; old ways of delivering important information services to farmers are being challenged; and traditional societies are being transformed into knowledge societies all over the world (Chadwick, 2006). Information is a major input to boost agricultural productivity and informatio0n communications technologies (ICTs) are therefore important to farmers for easier access to input and markets. This was why Nwachukwu and Ekanem (2016) opined that rural area should be provided with basic infrastructure such as electricity and good network so as to bring modern ICT services closer to the people for ease of access ICTs when available to rural farmers will improve the availability and quality of information either indirectly through producers associations, extension workers and he like or directly through broadcast radio information and mobile phone messaging ICT in agriculture is an emerging field focusing on the enhancement of agriculture and rural development. ICT can provide with accurate information necessary to facilitates better agriculture output.

Problem Militating Against the Use of ICTs by the Rural Farmers

Studies within Africa and other developing countries illustrate that these problems are particularly associated with the social and cultural limitations that farmers encounter. In the traditional environment that characterizes most developing countries (Nwachukwu, and Ekanem, 2016). Also Agbamu, (2013) and Uguru, (2015) were of the opinion that several challenges and barriers to ICT application can be identified such as; lack of infrastructure in developing countries and need her skills associated with the use of new technologies by rural communities and stakeholders, the resistance to these new ICT tools by stakeholders involved in extension processes and slow incorporation of these ICTs in communities.

In Nigeria, farmers, most especially, smallholder farmers, experience many challenges with respect to information dissemination, cellular telephones caused by poor network, poverty, illiteracy, language barrier and accessibility of ICTs to increase their agricultural knowledge. Lack of infrastructure is found as the biggest challenge in employing ICT to solve agricultural information dissemination problems. Ejiogu-Okereke *et al.* (2017) and Omotayo (2011) stated that the cost of purchasing a radio and television sets, cost of purchasing printed media such as newspapers, magazines, bulletins, and lack of infrastructural facilities especially electricity, wrong timing of agricultural programs and low literacy among the farmers are factors militating against use the ICT. According to Statista (2020) many developing countries lack sufficient electricity supplies, especially in rural and

remote areas. Mostly affected with these problems of infrastructure are the rural areas where the key producers of agricultural goods reside. Other challenge is the `un-readiness` of the Nigeria farmers to adopt the use of ICTs with many farmers actually believing in the old saying `you cannot teach old new tricks`.

Conclusion and **Recommendations**

Information Communication Technologies are essential for sourcing and disseminating information on extension services delivery for agricultural production. ICTs help in knowledge sharing, training, vulnerability reduction and social inclusion. Farmers perceived that all the identified ICT facilities were beneficial and play an important role in enhancing their capacity. Therefore, increased productivity can only be achieved by communicating research findings to a large group of farmers in the shortest possible time. Hence, accessibility of ICT facilities by farmers were very low compare to the knowledge on ICTs and the facilities were not readily accessible to the farmers. Factors affecting the accessibility and utilization of ICTs by farmers included poor infrastructural facilities like electricity and high cost of purchasing ICTs facilities. Rural areas should be provided with necessary infrastructure such as electricity and good road networks to enable farmers access information and communication Technologies facilities

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Perceived Value And Patronage Of Urban Forestry Among Early Stage Undergraduate Students Of Agriculture In University Of Uyo, Nigeria

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Abstract: *This study assessed the influence of exposure to environmental development communication process on the individual's traits of higher education learners during their early stage of study in the Faculty of Agriculture, University of Uyo. Despite repeated education interventions to promote the need for environmental conservation and preservation, individuals are relentlessly involved in unfriendly activities that are injurious to the environment. This study focused on assessing the perceived value towards urban forestry practices, assessed induced consciousness to urban forestry and patronage of urban forestry facilities among the early stage students in the Faculty of Agriculture. Purposive sampling procedure was adopted and the intact class of Principles of Forestry Resource Management - FOR 211 in 2020 / 2021 served as the study population and sample for the study. A set of validated questionnaires were used for data collection from a total of 209 students and the data were analysis using incidence index, frequency count, percentage and relative rank order positioning. Varying pattern of magnitude of incidences were identified across the three variables in this study. Analysis of the incidence index pattern of the perceived value revealed two major underlying dimensions of the perceived value magnitude distribution that ranged from 0.8 to 0.99. Also, the influence of learning on induced consciousness to urban forestry showed two major underlying dimensions based on its magnitude distribution pattern. All the 10 items that measured induced consciousness after exposure to Principles of Forestry (FOR 211), scored between 0.813 – 0.966 index score implying 81 – 96% consciousness. The result of the patronage of urban forestry facilities revealed five major underlying dimensions of its magnitude distribution that ranged between 0.1 to 0.79. The students showed patronage tendencies via their affirmed incidence index to the 7 items patronage indicators. Only 3 items unlikely of any serious student, centred around regularity of visit, scored below 50% index of patronage. Based on the underlying dimensions, it was deduced across the three variables that exposure to behavioural change communication through FOR 211 influenced the students' human capital adjustments. The study recommended inclusion of practical session in the course synopsis for FOR 211 and introduction of environment-based course as one of the compulsory courses to the wider early- staged undergraduate students across all the faculties in the university.*

Keywords: Behavioural Change Communication, urban forestry, disposition, patronage

CITATION:

Inyang, E. M. and Daniels, K. S. (2023). Perceived Value, Induced Consciousness and Patronage of Urban Forestry among Early Stage Undergraduate Students of Agriculture in University of Uyo, Nigeria. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp 27-35.

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Introduction

Urban forest is defined as networks or systems comprising all woodlands, group of trees, and individual trees located in urban and peri-urban areas (Food and Agricultural Organization, 2017). They may visibly be presented as ornamental, street and parkland trees, protected forests and green areas and form a form a part of Urban Recreational Ecosystem Services (URES) which are important in improving the quality of life and overall health (Bertram and Rehdanz, 2015; and Tibesigwa *et al*. 2018); biodiversity and ecosystem protection functions (Kuhn *et al*., 2004) and climate change mitigation (Myeong *et al.,* 2006). The morphological characteristics (e.g., leaf area, stem diameter), functions (e.g., photosynthesis, evapotranspiration), and structure (e.g., species composition, spatial pattern) of trees provide a wide range of ecosystem services (ES) and benefits that can alleviate the adverse effects of urbanization (Nowak and Heisler, 2011).

Urban forestry facilities also known as urban green infrastructure provides economic, environmental, ecological, social and psychological benefits (Takyi *et al., 2018)*. Udofia *et al.,* (2018) reported that people are attracted to urban green space due to the beneficial services provided, which may vary for each user depending on their interests, culture, ethnicity and religion, as well as on their social and economic background. Well-managed and maintained green infrastructures had been reported in various climes globally to induce attractiveness because they contribute to social inclusion and justice, provide cultural links and opportunities for community events, provide an educational resource with regard to the environment and nature, and help improve the physical, psychological and mental health of locals of all ages by providing areas for recreation and exercise (Takyi *et al.,* 2018). Udofia *et al.,* (2018) and Daniel (2022) reported a high positive level of perception among the city dwellers on the social benefits of some of the urban forestry infrastructure in Uyo City. Among the reasons for patronage was offering opportunities for physical recreation and provision of space for social events and integration. This means a lot for community cohesion and healthy living.

Patronage occurs when an individual displays conscious effort to choose a solution towards his or her need(s) through the process of analyzing situations, and which one out of the available offers would be rewarding and relatively satisfying amidst some challenges encountered in the course of fulfilling his or her own desires. It can be inductive in nature, suggesting that the level of patronage is induced by some external conditions that prevail at a given time (Adiele and Joseph, 2018). Adiele and Etuk (2017) opined that an individual exhibits either conditional or unconditional patronage. While conditional patronage on the other hand, is common to goods and services that an individual intentionally or knowingly maximizes to meet their economic needs, unconditional patronage is mostly associated with expectations that give individual joy and satisfaction.

In ecotourism, attractiveness has been reported to influence future behaviour which can be expressed in terms of repeat visit, recommendations and positive word-of-mouth (Yoon and Uysal, 2005). Only dedicated tourists are more likely to revisit sites and the willingness of tourism consumers to recommend them and partake in positive word-of-mouth shows reliability and demonstrates a good level of attractiveness.

Active citizens are aware of the problems in society and their rights and responsibilities. They attempt to eliminate these problems making use of their rights, to fulfil their responsibilities and to involve societal activities (Fidan, 2016). This can only be done when they are environmentally conscious and sensitive. Environmental consciousness in this study holds as the level at

which someone knows the impact of human actions on the environment. Despite the varying positions of the explanations, once it falls within the concept of perceive role of ethics and responsibility (PRECOR) (Singhapakdi, 1996), it is tenable. There are internal and external determinants that influences environmental consciousness. While internal has to do with demographic, psychological and economic, external comes from media, culture and family (Hillman and Keim, 2001). In producing educationally responsible and sensitive individuals, environmental education is a significant step.

Learning, combined with environmental care, can stir students' consciousness for the environment and nature. Nurwidodo *et al*., (2020) has shown that students' environmental care is low when there is a lack of intention to understand, study and take part in solving environmental problems and the best way to restore environmental damage is to raise active citizens who are sensitive to their environment. Rahayu (2019) had reported student's curiosity and concern for the customs and culture that are learned, are crucial to shape students' environmental care profile. This can be achieved by using strategic environmental studies, facilitated by modifying the ethnoscience approach to explore local potential, customs, and culture.

Environmental education is geared towards creating a habit and a positive sensitivity in people to the environment (Nadiroh and Irdiyanayah, 2021). There is generally a lack of sufficient action to protect the environment, such as taking responsibility, exploring the local wisdom in a particular area, and maintaining and managing the environment. Taking care of the environment is an attitude that strives to prevent natural environmental damage. The absence of the implementation of contextual learning can limit meaningful experiences for students (Khori *at al.,* 2021). Environmental education impacts society by enhancing people's knowledge and awareness of the environment and induces environmental care behaviour. Knowledge of the environment has been positively associated with environmental care behaviour, which can abate environmental damage (Rahardjo, 2017)). This knowledge of environmental care can be imparted to students by integrating the environment into materials, methods, media, learning resources, and assessment (Khori *et al.,* 2021) in order to make them sensitively active.

It is certain that individuals relate with their environment at different capacity and dimensions (Fidan, 2016 and Yilmaz and Erkal, 2016). One way of prompting this consciousness is the introduction of students to environmental education and courses (Yimaz and Erkal, 2016; Nadiroh and Irdiyanayah, 2021). There have been concerted efforts over decades across Nigeria and despite such, it is debatable if most citizens have attained environmental consciousness because of increasing rise in environmental issues in relation to plant vegetation in both rural and urban centers. This scenario calls for questioning if various forms of environmentally related educational processes are effective? And can influence individual perceived value ecosystem, induced consciousness to forestry and increase patronage of forestry facilities. The benchmark of education is change in attitude, skill and knowledge of the beneficiaries, which remains the veritable means to influence the attitudinal dispositions shown by individuals towards the environment (Yimaz and Erkal, 2016) and explains the trend in environmental sensitivity towards environmental perturbation and resultant abuse or misused of the environmental resources. This study therefore assessed students' perceived value for urban forestry practices, assessed the influence of FOR 211 on students' consciousness to urban forestry and

the students' levels of patronage of the urban forestry facilities.

Methodology

The study was based on Expo-facto research design. The study was conducted within the Uyo Capital City, Akwa Ibom State. The study area lies between latitudes 4°55'30" and 5°7'30"N, and longitudes 7°51'0" and 8°20'30"E. The study area has a tropical climate marked by two distinct seasons namely, dry season (November – March) and wet season (April – October). The wet season is usually interrupted by a short dry weather in August which is often known as "August Break" (AKMoED, 2014). Average annual minimum and maximum temperatures of the State is 23.32^0 C and 31.29^0 C respectively. Study population consisted of all the students in the Faculty of Agriculture that offered FOR 211 – Principles of Forestry in the 2020/2021 academic session, therefore purposive sampling procedure was adopted, and the intact class was used as sample size because the study population serve as sample. A total of 209 people agreed to participate in the survey and received the earlier validated structured questionnaires. The structured questionnaire with different scaling options was used to collect data on perceived value, induced consciousness and patronage of urban forestry from the students. Cronbach's Alpha was employed to test the reliability of the items and the value of 0.714 was obtained for the perceived value, 0.823 for the patronage and 0.804 for the induced consciousness. The research had test and social construct variables, all of which were reflected in the objectives of the study. Social construct variables in the study were: five demographic characteristics of the respondents, environmental consciousness, patronage appeals, perceived value held about urban forestry. Descriptive statistics like incidence index, frequency counts and percentage were used to analyze the collected data.

Results and Discussion

A. The Students' Perceived Value for Urban Forestry Practice (PVUFP)

Variation in the students' judgements for each component of value held with respect to urban forestry practice they have come across are as shown in Table 1. The results on Incidence Index (II) column showed the proportion of respondents that expressed a value that the urban green infrastructure have for them. The indicators displayed various magnitudes of spread of values as depicted by the relative rank order position (RROP). But the relativity of these indicator revealed various ranges of decree of magnitude which were empirically observed according to categorization based on superscript a and b.

The results showed that the most ranked of the six UFP values was "avenue to be close to nature" with index value of 0.943 (about 94.3% affirmation) and a magnitude categorization "a". The second and third most cherished values of the UFP to the people were "serene landscape/ vegetation" with an index of 0.913 (91% affirmation) and "a good vista for enjoyment of sound and sight of birds" with an index of 0.899 (about 90% affirmation) respectively. While the second had a magnitude of "a" the third had a magnitude of "b". However, the value of affordable and untaxed space to seek novelty (Item 6) was virtually the least appreciated by the students. It had an index value of 0.833 representing a paltry 83.3% affirmation and an impact magnitude "b". Categories "a" suggested psychological contemplation while "b" suggested ecological and recreational values. The result is similar to Babalola and Raji (2016) who reported that majority of their respondents valued to be and work in environment with landscaped with trees. It further revealed why student are often seen having private moments or meditating under tree shades around campuses or relaxing in company of friends around areas landscaped with trees.

Table 1: Distribution of Respondent based on Perceived Value to Urban forestry Practice (UFP).

S/N	How does these statements on GI reflect you	SD	D	A	SA	UFP II & RROP
1	Provide avenue to be close to nature	1.9	3.8	42.1	52.2	[a] 0.943 1st
2	It provides grounds for solitude, seek quietness and meditation	2.4	6.2	30.1	61.2	[a] 0.913 2nd
3	It provides a good site to ease boredom	4.8	8.6	44.0	42.6	[b] 0.886 4th
4	It provides a serene landscape and vegetation	4.3	1.9	36.8	56.9	[b] 0.837 5th
5	It presents a good vista for enjoyment of sound and site of birds	3.8	6.2	39.7	50.2	[b] 0.899 3rd
6	It is an affordable and untaxed space to seek novelty	3.8	12.9	49.8	33.5	[b] 0.833 6th

Note: SD means Strongly Disagree, D means Disagree, A means Agree and SA means Strongly Agree

B. Influence of FOR 211 on students' Induced consciousness to urban forestry

Variations in the users' judgement on ten environmental consciousness of the students on exposure to FOR 211 are shown in Table 4. Incidence Index (II) columns showed the proportion of a particular element of consciousness that the course has stirred up in him/her, which were further ranked as depicted by the relative rank order position (RROP). The relativity of these indicators revealed three ranges of decree of magnitude which were empirically observed according to categorization based on superscript a - c.

All the ten items that reflected the possible post FOR 211 consciousness on urban green infrastructure, had index value of above 0.80 (over 80% affirmation). Deeper appreciation about environment, knowing more about functions of trees, appreciation of the importance conservation and interest to engage in urban conservation, obtained similar magnitude categorized "a" and ranked first, second, third and fourth consciousness respectively. The least ranked was ability to differentiate more trees by names than before, with index value 0.813 (about 81% affirmation) and magnitude categorization "C". Majority (91.5%) of the respondents expressed the need to have more green infrastructure in their environment. 51.7% of the respondents also ranked FOR 211 (above 5 score) as one of the most beneficial courses they offered in the semester. These results validated Fidan (2016) that conscious citizens attempt to right the wrongs and involve in societal activities and corroborated Rahayu (2019) on the curiosity of students in environmental care profile using strategic environmental studies. Such studies were imparted via teaching, learning resources and assessment as was the case in FOR 211

C. Students' Patronage of the Urban Forestry Facilities

Variation in the students' judgement for each component of value for UFP are shown in Table 3. The results on Incidence Index (II) column,.

Table 2: Showing Distribution of Respondents based on students' Induced consciousness to UFP on exposure to FOR 211

SN	How does these statements on FOR 211 reflect you with respect to your Environmental Consciousness	SD	D	A	SA	ICUFP II & RROP
1	It makes me appreciate environment the more	2.4	1.0	34.9	61.7	[a] 0.966 [1st]
2	I know more about functions of trees	1.9	1.9	35.9	60.3	[a] 0.962 [2nd]
3	I know more about the role of wild animals	4.3	8.1	49.3	38.3	[b] 0.876 [5th]
4	I know more about the potential of Nigeria forests	4.3	9.6	44.0	42.1	[b] 0.861 [8th]
5	I have known more on how to maintain trees	7.7	6.2	41.1	45.0	[b] 0.861[8th]
6	I can differentiate more trees by names than before	6.2	12.4	41.1	40.2	[b] 0.813 [10th]
7	I know more about urban green infrastructure than before	2.9	9.6	40.7	46.9	[b] 0.876 [5th]
8	I understand the uses of different tree species	2.9	10.5	45.0	41.6	[b] 0.866 [7th]
9	I appreciate why conservation is very important	2.4	1.9	25.8	69.9	[a] 0.957 [3rd]
10	I am very interested to engage in urban conservation	3.8	4.8	39.7	51.7	[a] 0.914[4th]

Note: SD means Strongly Disagree, D means Disagree, A means Agree and SA means Strongly Agree

showed the proportion of a particular attribute that was reflective of the student The indicators displayed various magnitude of spread of patronage as depicted by the relative rank order position (RROP). But the relativity of these indicator revealed various ranges of decree of magnitude which were empirically observed according to categorization based on superscript a - c. Seven questions indicating ways the students patronize the urban green infrastructure were considered. Responses were reported using a 4 four-point scale indicating the strength of patronage and "I would recommend the urban green infrastructure to others" with an index value of 0.732 and the magnitude categorized as "a", ranked the topmost patronage that the respondents had for the various UFP. This was followed by "I will do positive word-of-mouth to others" with index of 0.722 with magnitude category "a". The least ranked patronage was "visiting the facilities more than thrice a week" with an index of 0.168 and a magnitude categorized as "d". Category "a" suggested advocacy, "b" suggested visitation and "c" and "d" suggested time devotion.

It would be observed earlier that over 90% of the respondents agreed to the fact that areas with urban forestry interventions makes them close to nature and provided them with ground for solitude and meditation, they were willing to recommend the area to others, do positive word of mouth and likely revisit the area. These were in line with Adiele and Etuk (2017) report that when an individual derived joy and satisfaction

from a place or thing, he or she exhibits unconditional patronage and would be willing to recommend and partake in positive-word of mouth shows reliability and demonstrates a good level of attractiveness. Time devotion (weekly, monthly/ bi-monthly visits) was the least options of patronage by the students possibly because of the demand of their academic works and economic standings.

Table 3: Showing Distribution of Respondents based on patronage of the urban forestry facilities

SN	How does these resemble you	Not at all	Least of me	More of me	Typical of me	PURF II & RROP
1.	Not every month	12.0	22.5	25.4	40.2	[b] 0.656 [4th]
2	Every month but not every week	33.5	29.2	23.4	13.9	[c] 0.373 [5th]
3	At least once a week	38.8	34.9	12.9	13.4	[d] 0.263 [6th]
4	More than thrice (3x) a week	47.4	35.9	11.5	5.3	[e] 0.168 [7th]
5	I would like to visit the Park again	14.4	17.7	29.7	38.3	[b] 0.680 [3rd]
6	I would recommend the urban green infrastructure to others	10.0	16.7	32.1	41.1	[a] 0.732 [1st]
7	I will do positive word-of-mouth to others	12.4	15.3	42.1	30.1	[a] 0.722 [2nd]

Conclusion and Recommendations

The study concluded that exposure of the students to environmental course – Principles of Forestry (FOR 211), heightened the perceived value, induced consciousness and patronage levels of the students to the various urban forestry infrastructure, prompting their willingness to get involved in conservation of the urban greens. Based on underlying dimensions, it was deduced across the three variables that exposure to behavioural change communication through FOR 211 influenced the students' human capital adjustments on perceived value and induced consciousness but similar higher adjustments were not affirmed by the respondents with respect to patronage of urban forestry facilities. The study recommended inclusion of practical session in the course synopsis for FOR 211 and introduction of environment-based course as one of the compulsory courses to the wider early- staged undergraduate students across all the faculties in the university.

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A Review Of E- Agricultural Extension In Nigeria

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Abstract : *In the past years, agricultural extension in most African countries especially in Nigeria has been lagging due to several challenges such as the large farmer-to-extension agent ratio and other challenges such as poor infrastructures, which makes the extension system unable to efficiently render their services to farmers. Yet, given the prevalence of information and communication technologies (ICTs) in the country in this 21st century, many academics have asserted that the use of these cutting-edge technologies will enhance the sector by boosting its capacity and effectiveness. Therefore, an e- agricultural extension can be said to be a means of delivering and transferring information to farmers through the use of electronic devices and ICTs. The paper reviewed the various ICTs tools such as radios, televisions, videos/ CD ROMs, Cellphones/smart phones, computer/ internet services, social media, and other advanced ICTs, which when employed in agricultural extension can increase its efficiency in Nigeria. Several benefits such as; timely and relevant dissemination of information to farmers, transfer of information to a large number of farmers, thereby overcoming the issue of disproportionate extension agent to farmer ratio and connecting farmers to buyers and finance. Several challenges acknowledged were; poor network and satellite Infrastructures, lack of ICT skills and ignorance of the benefits of E-agricultural extension and high cost/maintenance of electronic technologies. It was recommended that ICT infrastructures should be established especially in the rural areas.*

Keywords: E-agricultural extension, extension agent, information, communication technologies

CITATION:
Etuk, U. R., Okoro, G. I. and Tombere, R. J. (2023). A Review of E- Agricultural Extension in Nigeria. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp.19- 26

INTRODUCTION:

Using a variety of communication techniques and strategies, agricultural extension effectively disseminates information so that farmers have access to timely, pertinent information that will increase their output. Thus, agricultural extension is crucial for supplying farmers with information. It is in this view that most African governments including the Nigerian governments have made significant strategic investments, working with foreign assistance groups to promote agricultural extension across the continent, and this effort has been faced with many challenges. Information and communication technologies (ICTs) are technologies used to manage information and enhance communication. They enable individuals to produce, gather, process and manage information in a number of ways.

Food and Agriculture Organization, (2017); Etuk *et al.*, (2017) and Etuk *et al.*, (2018) opined that in agricultural extension, supporting and connecting with farmers and their families, ICTs tend to do the work excellently. In recent years, much attention has been placed on the value of timely and relevant agricultural information, particularly with regard to the contribution of

information, communication, and technology (ICT) to the supply of farmers with the necessary agricultural information. Its use in e-extension for agricultural extension will inadvertently lead to the development of agriculture. According to Singh and Kumar (2015) and Etuk *et al*., (2018) the improvement of agricultural and rural development through enhanced information and communication technology processes is the emphasis of the new e-agricultural technology trend in Nigeria known as electronic agricultural extension technology. Thus, it is possible to define an e- agricultural extension as a method of providing information to farmers through the use of electronic devices and ICTs. Here, there is continual effective communication and knowledge transfer between the farmers and the extension workers without the necessity for face-to-face meetings. It is perceived that only electronic technology in agricultural extension will have the capacity of engaging a maximum number of farmers who are using android or basic phones, (Kamruzzaman *et al*., 2021). In summary, e-agricultural technology is the conception, design, development, testing, and use of modern information and communication technologies (IT) in the rural domain, with a primary focus on agriculture (Chauhan, 2015).

Tools Utilized in E- Agricultural Extension and their Application

The E-extension operates mainly through web portals, social media and mobile apps and therefore has several benefits over the traditional extension approaches, (Bhattacharyya, Patil, Bhave, Sawant, Haldankar, & Narkhede, 2018). It also involves the use of advanced electronic technologies such as Satellite systems, Global Positioning Systems (GPS), advanced computers and electronic systems which results in overall improvement of the agricultural sector.

These ICT tools and their applications in extension are as follows;

1) **Radio:** This is a mass medium that can assist the agricultural extension department in transferring information to farmers. This medium has been used for the longest time and is very efficient as it is cheaper to purchase by rural farmers in Nigeria compared to the cost of acquiring a television. It has the capacity for interaction, outstanding in giving persuasive programs and in passing general information to farmers. Examples include; The Bill and Melinda Gates Foundation, which funded the Farm Radio International programme known as the African Farm Radio Research Initiative (AFRRI), and it was carried out over two phases in Ghana, Malawi, Tanzania, Mali, and Uganda. It attempted to find and document the most successful strategies for delivering agricultural knowledge to smallholder farmers in Africa and the initiative was deemed a success, (Farm Radio International, 2011)
2) Television: this is another mass medium, however, with a visual capacity that enables the extension department to conduct training demonstrations via this medium for the farmers. Programs shown using this medium are more engaging than radio as it appeals to both the visual and audio senses. Update on the current market situation, general notices and opportunities can be done using this medium.
3) Videos/ CD ROMs: Training, classes or conferences are recorded for farmers, acting as reference material and source of valuable information to farmers. Farmers can also use recorded videos and CD ROMS for self and group study, as well as a means of sending feedback and communicating with extension agents, serving as a means of feedback. An example is Access Agriculture; it connects people throughout the world to high-quality training videos in their native languages. Digital green; was developed as a modern

innovation to tackle food scarcity by leveraging cutting-edge technological discoveries to assist impoverished farmers (Akpabio et al., 2018).

4) Mobile phones/ Smartphone devices: these are electronic devices for communication, which promotes timely transfer of information between farmers and extension agents irrespective of their locations. Smartphones enable access to videos and web applications. It can be used to transfer short text messages, videos, and pictures among farmers and between extension personnel and farmers.
5) Computer and Internet: Information is accessed via this medium by both farmers, and extension agents when they are connected to the internet. Microsoft packages like excel, ms-word installed in computers can enable access farm management tools for record keeping; a means of saving information for reference which can be shared with other farmers and amongst the extension staff.
6) Social Media: this can be accessed via phones and computers with available internet/ network. This is a very popular medium utilized especially by the youths. Through this medium, it is possible to exchange agricultural information between advisors and farmers, and helps connect farmers with interested buyers and investors, opening an easier path to economic access. Examples; Facebook, WhatsApp, TikTok, Instagram, etc.
7) Other advanced ICT tools include;
   - Geographic information systems (GIS), remote sensing (RS), and global positioning systems (GPS) can be combined for the management of animal diseases. Both GPS and GIS use georeferencing to collect and analyze data. Locations on Earth can be found using the Global Positioning System (GPS) and it also enables continuous (24 hours a day), real-time, three-dimensional positioning, navigation and timing around the world (Singh, Kumar, & Singh, 2015).
   - Database-driven websites and phone applications: these include AGMARKNET a comprehensive database which links together all the important agricultural produce markets, and Agri-Business Centers; provides web-based solutions for both large landowners and small and medium-sized farmers, bringing all agribusiness players together on one platform. These phone applications also include:

Agriculture Question Bank APK: Agriculture Question Bank is controlled by Agricapsule and it is an online platform with more than 2000questions and answers. This helps to assist students in their preparation for agriculture-related exams (Agri Question Bank, 2021). It also can be operated by farmers and extension agents as it helps to provide the answers to their questions.

Fieldmargin Apk: Fieldmargin creates simple-to-use software to assist farmers in managing their businesses. It enables farmers to easily keep accurate farm records by collecting all the data they need in one place to make better farming decisions, (Fieldmargin, 2014).

AgriSmart APK: This software is designed as a phone/computer application. AgriSmart provides farmers with a single login to control every aspect of their farm operations. Payroll is processed using a combination of piece rates, wages, activity code-linked wage rates, productivity bonuses, and attendance bonuses using biometric clocks and digital timesheets, (AgriSmart, 2022).

Agric media Tv APK: Digital AgriMedia TV is an e-Agriculture app basically used in India for agriculture education, extension, digitalization, and rural development. It is the most reputable organization in Gujarat and India for Indian

agriculture, particularly for farming. It seeks to enhance the power, commerce and professionalism of traditional agriculture, (AgriMedia TV : Hi-Tech Agriculture, 2021).

Benefits of E-Extension

ICT tools, and other web technologies offer several advantages and will bring positive developments in this field if used in agricultural extension. These benefits include the following;

- **E-Agricultural Extension enhances timely and relevant dissemination of information to farmers**:
  Efficient agricultural extension services, reducing global poverty and increasing agricultural production can be greatly aided by providing farmers with timely and relevant information, credit and higher market prices. This is not possible with traditional extension services, but with the application of ICTs such as radio, and television to Agricultural extension services, information can be timely transferred to the targeted audience
- **It ensures information transfer to a large number of farmers, thereby overcoming the issue of disproportionate extension agent-to-farmer ratio:** Kamruzzaman *et al*., (2021) observed that E-Agricultural Extension technology is the only strategy to reach as many farmers as possible. In this 21st century, mobile phones are becoming a necessity for both young and old farmers, and are owned even in rural areas, especially the basic phones. In addition, broadcasting agricultural news using electronic media such as radio and television makes it possible to transmit information to many farmers simultaneously, reducing the burden on extension agents due to the unbalanced ratio between extension workers and farmers. In this sense, electronic technology can greatly improve both personal contact and access to information, thus filling the information gaps left by public extension in crises and emergencies, as there are not enough extension workers to reach out to farmers, and are often faced with limited resources, (Ferri *et al*., 2020).
- **E- Extension connects farmers to buyers and finances**: (Aker *et al*., 2016) informed that farmers become more competitive in the market through the application of e-extension services which connects farmers to consumers of their products and encourage the use of digital financial services, such as loans, to grow their farms, and eradicates unwanted middlemen activities.
- **The employment of E- Agricultural Extension in agriculture makes it attractive to the youths**: The use of electronic innovations helps simplify and share new knowledge of agriculture to farmers, it creates easy access to collaborative support thereby promoting the sectors' attractiveness, especially to the younger generation.
- **E-extension system directly improves farmers' income:** Bhave *et al*., (2018) reported that E-agricultural extension technology helps improves farmers' income by reducing the time between the need for and application of agricultural technology, reduction of cost and waste, assists farmers by enabling them to participate in decision support systems, and improves the traceability of agricultural products thereby encouraging food certification.
- **Efficient and effective use of E- agricultural extension in agriculture can lead to precision farming:** Bhave *et al.,* (2018) also proposed that precision farming could be accomplished through the use of electronic agricultural extension technologies and the adoption of advanced technology. It involves informing extension staff and farmers about a range of threats and emergencies, including weather changes, natural disasters,

price uncertainty, personal risks, and abrupt institutional and policy changes that have a significant impact on input use, investment, and technology adoption decisions. (Muhammad *et al*., 2018)

- **E-agricultural extension is suitable for emergencies and is the best replacement for traditional extension systems**: Conventional in-person communication networks cannot meet up the standard and requirements during emergency situations, therefore participating in low-cost digital tools is necessary to give farmers the information and market connections they require, gathering real-time data on the challenges on the ground, and adapting these tools to tackle new challenges becomes urgent priorities. Now, agricultural knowledge and assistance are available and easily accessible to millions of farmers worldwide courtesy of electronic agricultural extension (Olagunju *et al*., 2021).

Challenges of E-Extension

Notwithstanding the numerous benefits of E-agricultural extension, and it thrives in other countries, the system is faced with several challenges in various parts of Nigeria (Onah *et al*., 2021). These challenges are as follows;

- **Poor network and satellite Infrastructures**: In order to access agricultural information from databases of private and public agricultural education and extension agencies, it will need a good internet setup and network at both ends (i.e., the farmers' location and extension agents' location). However, that seems to be a problem in Nigeria due to poor network and satellite infrastructure (Akpabio *et al.*, 2018)).
- **Lack of ICT skills and ignorance of the benefits of E-agricultural extension:** Most agricultural activities in Nigeria take place in rural locations where most farmers lack the IT skills necessary to operate electronic agricultural extension services. While some educated farmers who possess these ICT abilities, living in locations with good networks are unaware of the necessity of e-agricultural education and extension in the twenty-first century (Onah *et al.*, 2021).
- **High cost/maintenance of electronic technologies**: Electronic technologies are of highly expensive, especially the advanced ICT tools, and without the support of the government, it is difficult for the agricultural extension department to acquire and implement them in their services. More so, maintenance of these ICT facilities is costly, and discourages both the agricultural extension agencies and farmers to adopt these electronic technologies in the sector.
- **Insufficient use of electronic technology**: Agricultural extension workers reveal that an effective electronic method of providing farmers with agricultural information through information-based websites, daily or weekly SMS, radio, TV, satellites, etc. has not been properly used despite the lack of personnel for agricultural education and extension services (Akpabio *et al.*, 2020 and Onah *et al.*, 2021).
- **Poor understanding of potentials of e-extension**: Lack of knowledge regarding how electronic technology might be used to manage agricultural dangers and emergencies in Nigeria has resulted in a less focused usage of electronic technology in agriculture (Khan, *et al*., 2020).
- **There are not many policies that support e-agriculture extensions**: There are few empirical studies, and policies that supports e-agriculture/ e-agricultural extension in Nigeria. This is due to a lack of understanding among farmers, educators, government officials, and private agricultural extension

organisations about the 21st century's potential for e-agricultural education and extension, (Onah *et al*., 2021).

Conclusion and Recommendations

There are numerous potentials and benefits involved in the application of electronic technologies to agricultural extension, it can therefore be concluded that e-agricultural extension is, a prerequisite for the achievement of substantial agricultural growth and development. These ICTs when applied to extension services will boost the capacities of extension agents enabling them to overcome the difficulties encountered as a result of the disproportionate extension agent-to-farmer ratio which is a prevailing issue in the system.

In this current era where electronic technologies/ ICTs are largely appreciated, the agricultural sector, especially the agricultural extension agency (both public and private extension agencies) in Nigeria, must adopt this electronic technology, as it will go a long way in promoting the growth of the sector. Also, farmers and extension agents should be adequately trained in ICT skills/operations, to ensure effective adoption, since the primary place for agriculture in Nigeria is the rural areas, and extension services are focused in these areas, the government should therefore ensure that ICT infrastructures including a steady supply of energy, a strong network for internet connectivity, phone booths, cybercafés, etc. are created.

Furthermore, there should be an interaction between representatives from the government, the agricultural extension department (both for the private and public agencies) and most importantly from the rural farming community to bring up suitable policies to support electronic agricultural extension in the country, and programmes involving e-extension should be put into action.

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Evaluation Of Genotype Effect On The Morphometric Parameters Of Nigerian Indigenous Chicken Genotypes

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Abstract: *The study evaluated genotype effect on the morphometric parameters of Nigerian indigenous chicken genotypes. This study was carried out in the Teaching and research farm of FUNAAB. Nigerian Indigenous Normal feathered (N), Frizzle-feathered (Fz) and Naked neck (Nk) chickens were crossed with Marshall (M) Exotic breed to obtain F_1cross (MN, MNk and MFz) used for the study. Genotype was regarded treatment. The design of the experiment was CRD. Data were collected on growth traits (body weight (BW), body length (BL), breast girth(BG), thigh length(TL) and keel length(KL)) from day-old to 8weeks of termination. Data collected were analyzed using the General Linear Model of Statistical Analysis System. Results showed that genotype significantly ($p<0.0001$) affected body weight and linear body parameters in this study. At 8th week, body weight was 904.38±25.16 g, 816.52±23.89 g, 805.24±21.68 g for MNk, MFz and MN chickens, respectively and 791.92±17.95 g, 637.05±17.96 g and 619.71±19.18 g were recorded for Fz, Nk and N, respectively. MNK cross had the highest (904.38±25.16 g) among the di-hybrids while Fz had the highest (791.92±17.95 g) amongst the purebreds. The same trend noticed for body weight was observed for linear body parameters. Marshall had the highest values in all the linear body measurements, as a control followed by MNK cross while Fz purebred was the last. In conclusion, the MNK cross was the best performed genotype of all the genotypes of Nigerian Indigenous Chickens measured regarding growth traits in this study. Hence, crossbreeding is one of the best improvement tools in growth development in Nigerian Indigenous Chickens measured in this study*

Key words: Chicken, genotype, Indigenous, Morphometric, Parameters.

CITATION:

Udoh, J. E., Mbaba, E. N. and Unah, U. L. (2023). Evaluation of Genotype Effect on The Morphometric Parameters of Nigerian Indigenous Chicken Genotypes. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 9-18

1.0 Introduction

Chicken which has a significant impact on fundamental biology is a major source of protein worldwide. It is a widely acceptable livestock which serves as an ideal model for examining animal growth trait development and for sufficient supply of animal protein to the humans (Xu *et al*., 2013). It has some interesting economic traits such as short reproductive cycle and are highly prolific which greatly increased productivity. Nigerian indigenous chickens with their slow growth rate and small bodied size due to their production systems (free-range low input, backyard and semi-intensive) compared to the exotic breeds of chickens reared intensively, and had been selected for fast growth rate over time as such need some improvement measures to adopt such as selection, crossbreeding as well as intensive system of production in order to

transform Nigerian poultry industry (Peters *et al.,* 2000). Marker-assisted selection (MAS) which increase selection efficiency can linked with quantitative traits loci and serves in direct selection of genotype which further improves production traits (Lamont *et al.,* 1996). A good mating combination of the breeding stock should produce offspring which are improved in growth rate, efficiency of feed conversion and reproductive traits with less production cost. A programme which will allow a successful selection when associating productive traits of interest are carefully selected or improved few traits at a time rather than all at once, will be expected of greater genetic progress in any meat chicken (Adebambo *et al*., 1999). Understanding the genetic control of growth in chickens will provide an opportunity for the genetic improvement of production performance and physiology (Li *et al*., 2003). The rationale of conservation and sustainable use of indigenous chicken (IC) resources requires their Morph biometrical characterization Habimana *et al*., (2020). Hence, this study aimed at evaluation of genotype effect on the morphometric parameters, heritability and genetic correlations of Nigerian Indigenous Chickens.

2.0 Materials and methods

2.1 Experimental site

The research was carried out at the Poultry Breeding Unit of the University Teaching and Research Farm of Federal University of Agriculture, Abeokuta. Abeokuta is at latitude 7º10`N and longitude 3º2`E in Ogun State, Nigeria, with a mean annual rainfall of about 1037mm and mean monthly temperature of between 28- 36ºC (University Meteorological Unit, 2021).

2.2 Experimental stock

Pure indigenous chicken genotypes reared in the breeding unit of the University's Research Farm were used as parent stock comprising of pure cocks and hens of Normal feathered (N), Frizzle feathered (Fz), naked neck (Nk) and Pure Marshall Exotic (M) as a control for improvement to generate the progeny which were cross through artificial insemination method. The combination of these four genotypes at different bloodlines resulted in genotypes used in this study: 100% pure breeds (N, Fz, Nk), 50:50% M: Ind (di-hybrid) (NM, MFz, MNk), fifty chickens per genotype (sample size) making a population of three hundred and fifty chickens.

2.3 Egg collection, incubation and hatching

Eggs from each mating group were collected daily and labelled according to sire-line. The eggs were then transferred to the University's Teaching and Research farm hatchery unit for incubation and hatching. Eggs were sorted before incubation. On the 18th day of incubation, candling was conducted and number of fertile eggs were recorded. On the 21st day chicks were collected and the number of hatched chicks was recorded.

2.4 Housing, feeding and management

Chicks obtained were identified by wing-tagged immediately after hatched in respects to their sire line. From the hatchery chicks were stocked in a prepared brooder according to the genetic groups. The chicks were brooded for 3 weeks. Adequate management and health care were taken. The chicks were fed for 3 weeks with commercial starter ration that contain 23% crude protein and 2950 Kcal/Kg Metabolizable energy (ME) and water *ad libitum*. At four weeks of age, chicks were sexed and transferred to a compartmentalized deep litter system to accommodate 50 birds per genotype randomly allotted and fed with grower mash (20 CP and 3000Kcal/Kg (ME)) till six weeks then switched to finisher ration that supplied 19% CP and 3020 Kcal/Kg (ME) from six weeks till eight weeks of weeks of termination.

2.5 Data collection Growth

The chicks body weights (BW) were weighed weekly from day old to 8 weeks of age with the use of a weighing scale with 0.1g limit of

sensitivity in the morning before feeding. Linear body measurements were taken from day-old to 8 weeks using tape rule. **Body length (BL)** was measured from the vertebral region, to the base of neck to the hollow part at the base of the tail. **Thigh length (TL)** was measured as the distance between the patella (knee cap) and the posterior end of the tibia joining the tarso-metatarsus. **Breast girth (BG)** was measured as the bird's circumference around the deepest region of the breast; excluding the wings with tape rule. **Keel length (KL)** was measured as the length of the bird's sternum or breast plate from the hollow of the V-bone all with a tape rule.

2.6 Statistical analyses

Analysis of variance for the body parameters was carried out with SAS (2010, v. 9.2) Software using General Linear Model. Means were separated using Duncans Multiple Range Test at probability of 5% level. **Model 1:**

$Y_{ijk} = \mu + G_i + \varepsilon_{ij}$

Y_{ijk} = Observation of the $_i^{th}$ genotype on the $_j^{th}$Chickens

μ = Overall mean

G_i = Effect of the $_i^{th}$ chick genotype ($_i$ = 1, 2 …10)

ε_{ij} = Error due to individual observation

RESULTS AND DICUSSION

Effect of genotype on the growth traits

Genotype significantly (p<0.0001) affected body weight and all the linear body parameters measured at weeks 0 to 8 in this study.

The least square means of body weights (BW) and linear body parameters as affected by genotype are presented in Tables 1 to 5. M breed had the highest mean body weight from 0 to 8 weeks being the control. Amongst the purebred, the body weight of purebred indigenous chickens were not significantly (p>0.0001) different from each other from 0 to 3 weeks. At weeks 4 to 8 purebred Fz genotype had values statistically (p<0.0001) higher (243.05±10.21 g, 342.31±13.44 g, 497.93 g±12.45 g, 632.69±15.58 g, 791.92±17.95 g) than Nk (217.35±8.72 g, 289.08±10.98 g, 371.62±12.36 g, 543.86±12.56 g, 637.05±17.69) and N (207.89±7.60 g, 276.44±8.88 g, 345.67±12.22 g, 519.40±12.35 g, 619.71±19.18 g) genotypes.

Comparison of means of the F_1 crossbreds revealed that the body weights of MN, MFz and MNk were not significantly different at all ages except at 3rd and 8th week in which the MNk chickens with 251.12±4.81 g, 904.38±25.16 g were statistically (p< 0.0001) higher than MFz (225.26±6.72 g, 816.52 g±23.89 g) and MN (214.038.65 g, 805.24±21.68 g) but at 0 week (day old) MFz (35.53±0.39 g) was statistically (p< 0.0001) higher than MN (33.50±0.73 g) and MNk (32.23±0.53 g) genotypes. Generally, the values obtained for body weights (Table 1) showed that, the F_1 crosses had higher mean body weights while purebreds indigenous were the least.

Effect of genotypes on linear body measurements

The results of the analysis revealed that genotype significantly (p<0.0001) affected all linear parameters (body length (BL), breast girth (BG), thigh length (TL) and keel length (KL)) from 0 to 8 weeks measured. The mean values for BL, BG, TL and KL followed the same pattern noticed for body weights at all ages. Between the Nigerian indigenous chickens, Fz had higher values significantly (p<0.0001) different from others at different ages from weeks 6 to 8 in BG and TL as shown in Tables 2 to 5.

The least square means of BL at all ages (Table 2) showed that F_1 crosses had values next to M breed (control). Comparison within the F_1 crosses showed that MNk had values in BL statistically (p>0.0001) similar to MFz except at day-old and week 4 that MFz had 4.70±0.06 cm, 9.50±0.09 cm significantly (p<0.0001) higher than 4.35±0.11 cm, 9.44±0.13 cm of

MNk. However, MNk had higher values from 3 to 8 weeks of age with 8.12±40.13 cm, 9.44±0.13 cm, 10.77±0.09 cm, 12.09±0.11 cm, 13.60±0.16 cm, 15.49±0.16 cm significantly ($p<0.0001$) different from MN cross (7.25±0.12 cm, 7.69±0.13 cm, 9.38±0.15 cm, 10.73±0.18 cm, 12.52±0.20 cm and 14.53±0.22 cm) although at day old MN with 4.60±0.05 cm was statistically ($p<0.0001$) different from MNk (4.35±0.11 cm) genotypes. MNk cross had the highest values in BL among the F_1 crosses while MN performance was the least.

Comparison between indigenous purebreds revealed that Fz purebred were not statistically ($p>0.0001$) different from the other purebreds except at weeks 1, 5 to 8, that Fz purebred chickens (5.30±0.09 cm, 9.12±0.21 cm, 10.57±0.16 cm, 12.28±0.19 cm and 13.90±0.21 cm) were statistically ($p<0.0001$) higher than N purebred of 5.04±0.07 cm, 8.46±0.16 cm, 9.72±0.16 cm, 11.08±0.14 cm and 12.42±0.16 cm. Fz genotype performed best of all the indigenous purebreds while N genotype was the least. Generally, the F_1 crosses had longer in BL while purebred indigenous were the last.

Comparison between F_1Crosses revealed that MNk had the widest BG of 9.18±0.12 cm, 10.55±0.13 cm, 14.26±0.23 cm, 16.24±0.24 cm,18.38±0.27 cm, 20.94±0.33 cm for weeks 2, 3, 5 to 8 statistically ($p<0.0001$) different from MF (8.77±0.12 cm, 9.91±0.16 cm, 13.66±0.17 cm, 15.36±0.19 cm, 17.13±0.24 cm, 19.21±0.28 cm) and MN (8.37±0.15 cm, 9.49±0.18 cm, 12.07±0.23 cm, 14.01±0.25 cm, 16.32±0.31 cm, 18.61±0.37 cm) as well as week 4 of 10.93±0.22 while MFz of 12.37±0.16 cm was higher respectively but similar at weeks 0, 4. Among the Nigerian purebred indigenous, Fz genotype had the widest ($p<0.0001$) BG mean values in weeks 1, 5 and 8 of 7.07±0.09 cm, 12.01±0.19 cm, 16.77±0.22 cm than Nk (6.62±0.07 cm, 11.39±0.29 cm, 16.00±0.38 cm) and N chickens (6.59±0.13 cm, 10.66±0.17 cm, 15.33±0.26) cm, also Fz was higher ($p<0.0001$) in values at weeks 2, 3, 4, 6, 7 (8.15±0.14 cm, 9.57±0.14 cm, 10.90±0.17 cm, 13.19±0.20 cm, 14.81±0.21 cm) than N with 7.45±0.07 cm, 8.36±0.11 cm, 9.37±0.14 cm, 11.97±0.19 cm, 13.32±0.20 cm but relatively similar to Nk genotype. MFz had a wider breast girth while the purebred indigenous came least.

Comparison between all the F_1 crosses were similar in TL values at all ages except at 4 and 6 weeks that MNk with 92.92±0.14 cm and 12.48±0.16 cm were significantly ($p<0.0001$) higher than MFz (9.36±0.13 cm, 11.62±0.16 cm) and MN (9.37±0.11 cm, 11.45±0.20 cm). Also, at weeks 0, 2, 3, 5, 7, 8 MNk genotype with 5.23±0.03 cm, 7.34±0.08 cm, 8.02±0.10 cm, 10.97±0.08 cm, 13.96±0.18 cm and 16.17±0.19 cm were significantly ($p<0.0001$) higher in values than MN cross (5.05±0.04 cm, 7.21±0.09 cm, 8.11±0.11 cm, 10.31±0.13 cm, 13.41±0.17 cm and 15.33±0.16 cm).

Among the purebreds indigenous Fz was significantly ($p<0.0001$) different from Nk and N genotypes at weeks 6, 7 and 8 (Table 4).

Within F_1 crosses, Marshall Naked Neck was statistically ($p<0.0001$) higher than other F_1 crosses at weeks 2, 4, 7 and 8 (Table 4). Frizzle-feathered purebreds were significantly ($p<0.0001$) higher at weeks 2, 3, 4 and 5 than the Naked Neck and Normal feathered purebreds as presented in Table 5.

Generally, the performance in this study reflected this trend of the leading genotype being 50:50% Marshall: Indigenous bloodline (di-hybrid) while the purebred indigenous genotype came last. The results of BW as affected by genotype showed that M breed as a control performed better than followed by F_1 (50:50% M: Ind) cross then purebred indigenous as the last. The M breed being exotic which was known for intense selection for fast growth rate over time was expected to have the highest weight. The reason could be as a result of heterosis also due

to high percentage of exotic blood incorporated which transferred the fast growth rate and high meat yield qualities to the progeny compared to the indigenous blood in the genotype. This improved the slow growth rate and light breed qualities of the Nigerian indigenous chicken. This higher performance of the offspring when traced back to the performance of the stock confirmed the existence of heterosis as was also observed by Peters (2005).

Within the F_1 crosses, MNK cross had higher mean values superior to MFz cross while Normal feathered cross was the least, hence, MNK emerged the best performed genotype in this study. From the result of this study Frizzle-feathered was the heaviest genotype of all the three purebred Nigerian indigenous chicken genotypes followed by Naked Neck and then the Normal feathered. Adedeji *et al*. (2004) corroborated this result that Naked Neck and Frizzled-Feathered chickens performed better than Normal feathered types in body weight and linear body measurement traits.

Exotic genotype performed best in all the linear body parameters as expected of the control. The better performance found in thigh lengths observed in the F_1crosses could be attributed to the present of indigenous blood in the genotype. Long thigh is one of the adaptive features which served the Nigerian indigenous chickens from environmental stress both in feeding and escaping of some environmental dangers while the shortness of the thigh lengths of exotic breed were for better support of its heavy bodied weight preventing the birds from paralyzing. The short thigh lengths observed for Marshall Breed was in concurrent with the observation of Deeb and Lamout (2002) who reported that the shortness of the shank and thigh lengths of the exotic breed were to support its heavy-bodied weight. This was supported by Adebambo *et al*. (2010) who reported the long shank and thigh lengths in Nigerian chickens.

It was also observed that there was a steady and gradual increment in growth rate both in body weight and other body parameters at all ages. This findings is in consonance with the observation by Peters (2005); Adebambo *et al*. (2010) who observed the growth pattern of Nigerian chickens to be in a steady and gradual increment. The steady and gradual growth increment of Nigerian birds observed in the present study was also observed by Adedeji *et al*. (2008). At late age of between 6 and 8 weeks the rate of growth increment was rapid, this could be attributed to sex dimorphism as corroborated by Ikeobi *et al*. (1996) who stated the onset of sexual dimorphism to be visible from week 6 to 8.

MNK cross performance in breast girth and keel length was quite similar to those of the Marshall, although the Marshall mean values were higher. Marshall exotic (Control) had superior values in breast girth and keel lengths on considering the number of the genotypes involved in this study, the fact remain the same that Marshall exotic breed had been developed and selected over time for meat potentials and fast growth quality.

However, considering the Nigerian chickens in this study, MNK cross had the widest breast girth and the longest keel lengths which are the choice parts in broiler meat production. Among the F_1 cross MNK cross was the best while MFz was next and MN had the least means for the breast girth and keel lengths. This was due to the same reason of having 50% exotic genetic contribution which impacted the fast growth rate and high meat yield. This result further proved that crossbreeding is a tool for genetic improvement of Nigerian indigenous breeds. This finding confirmed the conclusion of Adebambo *et al.* (1996) and Peters (2005); Peters *et al*. (2008) and Adeleke *et al.* 2011) that Nigerian indigenous chicken has the potentials for genetic improvement.

Table 1: Effect of genotype on body weight (LSM±SE) (g)

Genotype	N	0	1	2	Weeks 3	4	5	6	7	8
MXM	50	39.25± 0.60^{a}	122.28±3.56^{a}	222.56±8.43^{a}	335.31±9.62^{a}	454.45±12.78^{a}	617.57±17.80^{a}	803.56±23.12^{a}	1037.45±34.20^{a}	1252.25±40.94^{a}
NXN	50	30.82±0.72^{de}	61.44±1.69^{d}	97.20±2.96^{e}	148.05±8.55^{d}	207.89±7.60^{e}	276.44±8.88^{e}	345.67±12.22^{e}	519.40±12.35^{d}	619.71±19.18^{e}
FzXFz	46	29.87± 0.30^{e}	68.87±1.99^{e}	109.92±3.56^{de}	154.93±5.95^{d}	243.05±10.21^{c}	342.31±13.44^{e}	497.93±12.45^{c}	632.69±15.58^{bc}	791.92±17.95^{d}
NKXNK	48	33.97±1.29^{bc}	64.78±1.40^{cd}	107.30±5.69^{de}	149.75±8.13^{d}	217.35±8.72^{d}	289.08±10.98^{d}	371.62±12.36^{d}	543.86±12.56^{e}	637.05±17.96^{de}
MXN	49	33.50±0.73^{c}	69.02±2.43^{e}	117.89±3.91^{d}	214.03±8.65^{c}	318.18±9.03^{b}	425.59±12.87^{b}	522.49±9.94^{bc}	657.48±16.76^{be}	805.24±21.68^{e}
MXFz	48	35.53±0.39^{b}	70.30±1.80^{be}	133.86±3.25^{c}	225.26±6.72^{c}	327.02±11.29^{b}	428.05± 8.61^{b}	548.34±15.69^{b}	669.14±20.94^{bc}	816.52±23.89^{c}
MXNK	50	32.23±0.53^{cd}	75.14±1.73^{b}	147.66±4.39^{b}	251.12±4.81^{b}	334.46±6.28^{b}	435.57±13.53^{b}	548.29±16.30^{b}	700.89±19.97^{b}	904.38±25.16^{b}

$^{a, b, c, d, e, f, g}$ *Means within the same column with same superscripts are not significantly different. MxM-Pure Marshall, NxN- Pure Normal-feathered, Fzx Fz-Pure Frizzle-feathered, NKxNK-Pure naked neck, MxN-Dihybrid Normal-Feathered, MxFz-dihybrid Frizzle-Feathered, MxNK-dihybrid Naked Neck, MxMxN-Normal-Neathered upgrade, MxMxFz-Frizzle upgrade, MxMxNK-Naked Neck upgrade*.

Table 2: Effect of genotype on body length (LSM±SE) (cm)

						Weeks				
Genotype	N	0	1	2	3	4	5	6	7	8
MXM	50	5.02±0.07^{a}	6.30±0.09^{a}	7.41±0.13^{a}	8.78±0.13^{a}	9.81±0.14^{a}	11.53±0.20^{a}	13.81±0.21^{a}	16.17±0.25^{a}	18.76±0.28^{a}
NXN	50	4.39±0.05^{cd}	5.04±0.07^{f}	5.82±0.07^{c}	6.61±0.10^{e}	8.18±0.14^{b}	8.46±0.16^{d}	9.72±0.16^{e}	11.08±0.14^{cd}	12.42±0.16^{d}
FzXFz	46	4.46±0.06^{cd}	5.30±0.09^{de}	6.05±0.10^{c}	6.92±0.13^{de}	8.06±0.16^{b}	9.12±0.21^{c}	10.57±0.16^{ed}	12.28±0.19^{c}	13.90±0.21^{c}
NKXNK	48	4.60±0.07^{bc}	5.17±0.06^{e}	6.08±0.12^{c}	6.99±0.16^{e}	8.08±0.17^{b}	9.17±0.17^{c}	10.30±0.23^{d}	11.93±0.25^{c}	13.34±0.28^{cd}
MXN	49	4.60±0.05^{bc}	5.42±0.07^{cd}	6.52±0.09^{a}	7.25±0.12^{d}	7.69±0.13^{c}	9.38±0.15^{c}	10.73±0.18^{e}	12.52±0.20^{b}	14.53±0.22^{b}
MXFz	46	4.70±0.06^{b}	5.46±0.08^{c}	6.69±0.11^{a}	7.97±0.12^{c}	9.50±0.09^{c}	10.66±0.16^{b}	12.04±0.17^{b}	13.50±0.16^{b}	14.90±0.29^{b}
MXNK	50	4.35±0.11^{d}	5.54±0.09^{b}	6.75±0.09^{a}	8.12±40.13^{b}	9.44±0.13^{a}	10.77±0.09^{b}	12.09±0.11^{b}	13.60±0.16^{b}	15.49±0.16^{b}

$^{a, b, c, d, e, f, g, h}$ *Means within the same column with same superscripts are not significantly different; MxM-Pure Marshall, NxN- Pure Normal-Feathered, Fzx Fz-Pure Frizzle-Feathered, NKxNK-Pure Naked Neck, MxN-Dihybrid Normal-Feathered, MxFz-dihybrid Frizzle-Feathered, MxNK-dihybrid Naked Neck, MxMxN-Normal-Feathered upgrade, MxMxFz-Frizzle upgrade, MxMxNK-Naked Neck upgrade.*

Table 3: Effect of genotype on breast girth (LSM±SE) (cm)

Genotype	N	0	1	2	3	4	5	6	7	8
M x M	50	5.31±0.04^{a}	6.57±0.07^{a}	9.30±1.97^{a}	9.43±0.15^{a}	11.14±0.17^{a}	12.24±0.16^{a}	14.80±0.26^{a}	16.31±0.31^{a}	16.49±0.24^{a}
N x N	50	5.18±0.03^{abc}	5.70±0.07^{f}	6.87±0.09^{b}	7.23±0.09^{f}	8.15±0.10^{e}	9.39±0.17^{f}	10.65±0.15^{f}	12.33±0.17^{f}	14.00±0.17^{e}
Fz x Fz	46	4.87±0.04^{d}	6.03±0.05^{de}	7.05±0.06^{b}	7.97±0.12^{d}	9.10±0.15^{cd}	9.86±0.18^{e}	11.73±0.12^{c}	13.37±0.23^{ed}	15.21±0.31^{d}
Nk x Nk	48	5.17±0.06^{ab}	5.93±0.07^{e}	7.02±0.08^{b}	7.89±0.11^{e}	8.95±0.13^{d}	9.77±0.20^{ef}	11.09±0.19^{e}	12.77±0.22	14.55±0.22^{f}
M x N	49	5.05±0.04^{c}	6.06±0.06^{be}	7.21±0.09^{b}	8.11±0.11^{b}	9.37±0.11^{c}	10.31±0.13^{d}	11.45±0.20^{de}	13.41±0.17^{c}	15.33±0.16^{ed}
M x Fz	46	5.26±0.06^{ab}	6.14±0.06^{b}	7.28±0.10^{ab}	8.09±0.11^{bc}	9.36±0.13^{c}	10.81±0.14^{c}	11.62±0.16^{d}	13.62±0.23$^{b\,e}$	15.98±0.18^{c}
M x Nk	50	5.23±0.03^{ab}	6.16±0.16^{b}	7.34±0.08^{a}	8.02±0.10^{bcd}	9.92±0.14^{b}	10.97±0.08^{b}	12.48±0.16^{b}	13.96±0.18^{b}	16.17±0.19^{b}

$^{a, b, c, d, e, f, g, h}$ *Means within the same column with same superscripts are not significantly different. MxM-Pure Marshall, NxN- Pure Normal-feathered, Fzx Fz-Pure Frizzle-Feathered, NKxNK-Pure Naked Neck, MxN-Dihybrid Normal-Feathered, MxFz-dihybrid Frizzle-Feathered, MxNK-dihybrid Naked Neck, MxMxN-Normal-Feathered upgrade, MxMxFz-Frizzle upgrade, MxMxNK-Naked Neck upgrade*

Table 4: Effect of genotype on Thigh length (LSM±SE) (cm)

		Weeks								
Genotype	N	0	1	2	3	4	5	6	7	8
M x M	50	1.45±0.01^{a}	2.87±0.52^{a}	3.48±0.05^{a}	4.64±0.07^{a}	5.79±0.08^{a}	7.02±0.10^{a}	8.03±0.12^{a}	9.65±0.18^{a}	10.83±0.20^{a}
N x N	50	0.96±0.01^{c}	1.67±0.03^{c}	2.33±0.05^{e}	2.94±0.07^{f}	3.62±0.08^{g}	4.47±0.11^{f}	5.34±0.13^{f}	6.06±0.14^{g}	7.10±0.12^{g}
Fz x Fz	46	1.18±0.18^{b}	2.01±0.03$^{b\,c}$	2.84±0.05^{c}	3.50±0.06^{d}	4.25±0.08^{e}	4.86±0.08^{e}	5.57±0.12^{d}	6.42±0.10^{e}	7.33±0.17^{e}
Nk x Nk	48	1.05±0.02^{bc}	1.94±0.03^{bc}	2.60±0.05^{d}	3.24±0.07^{e}	3.95±0.10^{f}	4.55±0.12^{f}	5.46±0.08^{e}	6.36±0.16^{f}	7.22±0.10^{f}
M x N	49	1.16±0.01^{b}	2.04±0.02^{bc}	2.88±0.06^{c}	3.70±0.07^{cd}	4.57±0.09^{c}	5.36±0.10^{cd}	6.50±0.09^{cd}	7.10±0.13^{d}	8.23±0.10^{d}
M x Fz	46	1.40±0.02^{a}	2.02±0.04^{bc}	2.90±0.07^{c}	3.75±0.07^{c}	4.56±0.09^{cd}	5.50±0.11^{c}	6.57±0.08^{c}	7.45±0.08^{c}	8.59±0.13^{c}
M x Nk	50	1.20±0.01^{b}	2.31±0.02^{b}	3.13±0.04^{b}	3.91±0.04^{b}	4.79±0.07^{b}	5.71±0.07^{b}	6.65±0.11^{b}	7.91±0.08^{b}	8.93±0.15^{b}

a , b , c, d ,e, f ,g , h Means within the same column with same superscripts are not significantly different, MxM-Pure Marshall, NxN- Pure Normal-feathered, Fzx Fz-Pure Frizzle-Feathered, NKxNK-Pure Naked Neck, MxN-Dihybrid Normal-Feathered, MxFz-dihybrid Frizzle-Feathered, MxNK-dihybrid Naked Neck, MxMxN-Normal-Neathered upgrade, MxMxFz-Frizzle-Feathered upgrade, MxMxNK-Naked Neck upgrade.

Table 5: Effect of genotype on keel length (LSM±SE) (cm)

						Weeks				
Genotpe	N	0	1	2	3	4	5	6	7	8
MXM	50	7.99±0.24^{a}	9.16±0.24^{a}	10.53±0.20^{a}	11.96±0.18^{a}	13.59±0.23^{a}	15.98±0.23^{a}	18.67±0.26^{a}	21.11±0.38^{a}	24.53±0.62^{a}
NXN	50	6.17±0.08^{e}	6.59±0.13^{ef}	7.45±0.07^{f}	8.36±0.11^{f}	9.37±0.14^{d}	10.66±0.17^{e}	11.97±0.19^{g}	13.32±0.20^{g}	15.33±0.26^{f}
FzXFz	46	5.80±0.08^{f}	7.07±0.09^{de}	8.15±0.14^{e}	9.57±0.14^{d}	10.90±0.17^{c}	12.01±0.19^{d}	13.19±0.20^{e}	14.81±0.21^{e}	16.77±0.22^{d}
NKXNK	48	6.31±0.08^{c}	6.62±0.07^{e}	8.06±0.14^{ef}	9.23±0.19^{e}	10.43±0.24^{c}	11.39±0.29^{f}	12.80±0.31^{f}	14.45±0.35^{f}	16.00±0.38^{e}
MXN	49	6.31±0.07^{c}	7.16±0.11^{d}	8.37±0.15^{d}	9.49±0.18d^{de}	10.93±0.22^{c}	12.07±0.23^{d}	14.01±0.25^{d}	16.32±0.31^{d}	18.61±0.37^{c}
MXFz	46	7.58±0.09^{b}	7.42±0.08^{e}	8.77±0.12^{c}	9.91±0.16^{e}	12.24±0.15^{b}	13.66±0.17^{c}	15.36±0.19^{c}	17.13±0.24^{c}	19.21±0.28^{c}
MXNK	50	6.01±0.09^{cd}	7.51±0.10^{b}	9.18±0.12^{b}	10.55±0.13^{b}	12.37±0.16^{b}	14.26±0.23^{b}	16.24±0.24^{b}	18.38±0.27^{b}	20.94±0.33^{b}

a , b , c, d ,e, f ,g , h Means within the same column with same superscripts are not significantly different, MxM-Pure Marshall, NxN- Pure Normal-Feathered, Fzx Fz-Pure Frizzle-Feathered, NKxNK-Pure Naked Neck, MxN-Dihybrid Normal-Feathered, MxFz-dihybrid Frizzle-Feathered, MxNK-dihybrid Naked Neck, MxMxN-Normal-Feathered upgrade, MxMxFz-Frizzle- Feathered upgrade, MxMxNK-Naked Neck upgrade.

Conclusion

The result of this study showed that genotype significantly influenced all the morphometric parameters measured at all ages in this study. The 50:50% Marshall: Indigenous bloodline (di-hybrid) was the leading genotype followed by the purebred indigenous in the general performance. Within the F_1 crosses, the MNK had highest mean values for growth traits measured superior to MN cross. Frizzle-feathered was the heaviest genotype of all the three purebred Nigerian indigenous chicken genotypes followed by Naked Neck and then the Normal feathered. It was also observed that there was a steady and gradual increment in growth rate both in body weight and in linear body parameters measured at all ages in this study. Considering the Nigerian broiler chickens in this study, MNK had the widest breast girth and the longest keel lengths followed by MFz then NF crosses. MNK cross was the best performed genotype of all the genotypes of Nigerian Indigenous Chickens measured regarding growth performance in this study. Hence, crossbreeding is one of the best improvement tools in growth development in Nigerian Indigenous Chickens measured in this study

Ethics approval

This research was carried out according to the ethical guidelines of the Institutional Animal Care and Use Committee (IACUC) of the University of Uyo through the approval of the Ethical Committee of the Department of Animal Science, Faculty of Agriculture, University of Uyo.

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The State of Precision Agriculture In Nigeria And Its Impact

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Abstract: *Due to Nigeria's economy's diversification and expansion, opportunities for precision agriculture have become apparent. Precision farming is replacing conventional agricultural methods in Nigeria. It is aimed at meeting the needs of increasing productivity of crops, livestock and fisheries in Nigeria through improved agricultural technologies. It was found that the majority of Nigerian farms and fields are too small to commercially profit from the current state of precision farming technology. However, it's likely that public concerns about food safety and the environment are starting to draw attention to the potential benefits of precision agriculture. Precision agriculture emerged in the twentieth century as a technology-driven means of developing industrialized agriculture. The processes taken in precision agriculture includes; field data collection; data analysis, decision making and data management. The key drivers of precision agriculture are technological innovations like Global Navigation Satellite Systems (GNSS), Geographic Information Systems (GIS), and microcomputers that are responsive to changes in soil and crop conditions, and aid the proper exploitation, collection, interpretation, and analysis of data gathered from various satellite technologies. This research examines the current state of precision agriculture in Nigeria and its impact.*

Keywords: Impact, Precision Agriculture, Nigeria

CITATION:
Udom, G. N., Obot, and Udoh, U. C. (2023). The State of Precision Agriculture in Nigeria and Its Impact. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp 1-8

1.0 Introduction

Technology has become man's greatest leverage since the turn of the century, and it has greatly impacted every of man's activities including agriculture. Technology is the wheel on which modern agricultural practices are thriving, and will continue to thrive. One major impact of technology is the birth of precision agriculture. Precision agriculture is a modern agricultural practice, a welcome technique for monitoring and regulating all of our resources to create sustainable information-based agricultural growth. Precision agriculture emerged in the twentieth century as a technology-driven means of developing industrialized agriculture. It promised benefits to both farmers and society through increasing production efficiency while improving stewardship of the environment (Srinivasan, 2006). Agriculture is the most important economic sector in many sub-Saharan African (SSA) countries such as Nigeria, contributing more than one-third of the gross national product (GNP) and employing more

than two-thirds of the labour force (FAO 2017), therefore, utilizing resources more effectively is necessary for sustained agricultural expansion, which necessitates the implementation of technology like precision agriculture. Over 70% of her population depending on it directly or indirectly for livelihood. It provides the bulk of employment, income and food for the rapidly growing population as well as supplying raw materials for agro-based industries (Isioye 2013). Abubakar (2010) identified that precision agriculture meets the need of increasing productivity of crops, livestock and fisheries in Nigeria through improved agricultural technologies.

The key drivers of precision agriculture are technological innovations like Global navigation satellite systems (GNSS), Geographic information systems (GIS), and microcomputers that are responsive to changes in soil and crop conditions, and aid the proper exploitation, collection, interpretation, and analysis of data gathered from various satellite technologies. Precision agriculture is an agricultural mechanization method which depends strongly on electronics, information communication technology with technical skill of man power for plant and animal specific needs respectively (Asoegwu and Asoegwu, 2007). Gary (2004) views precision agriculture as a comprehensive system designed to optimize agricultural production through the application of crop information advanced technology and management practice. The farm management approach known as precision agriculture is majorly built on information and technology systems. This aims at the application of technologies and principles to identify, analyze and manage spatial and temporal variabilities associated with all aspects of agricultural production within fields for near optimal profitability, sustainability, improving crop performance, protecting land resources and safe guarding the environment (McBratney and Whelan 1999). This research examines the current state of precision agriculture in Nigeria and its impact.

2.0 KEY ELEMENTS OF PRECISION AGRICULTURE

Measurement and comprehension of variability are fundamental to precision agriculture, and the primary components of precision agriculture must address variability. Isioye (2013) opined that precision farming requires the requisition, management, analysis and output of large amount of spatial and temporal data, also, it is concerned with spatial and temporal variability owing that it is information based and decision focused.

The following are the tools that aid in practicing precision agriculture efficiently:

- **Global Positioning System (GPS)**: Twenty-four (24) satellites make up the global positioning system (GPS), which transmits exact time and location data to receivers on the ground. It is used to locate the geolocation of yield data gathered and has a precision of one to three meters.
- **Geographical Information System (GIS):** GIS is composed of a software database system that saves, retrieves, analyzes, and displays geographically referenced data in a map-like style, such as data from GPS and yield monitors.
- **Yield Monitors**: These are agricultural yield measurement tools that are mounted to harvesting machinery. They are able to provide information on yield (kg/ha), total kg, ha/hour, hectare worked, grain moisture content, and more. They give agricultural production data on a consistent basis by distance or time (e.g., every second or every few meter). Regularly, the positioning information from the GPS device is received together with the yield data from the monitor, which is then both recorded and saved. With the use of GIS software, yield maps are generated.

- **Variable Rate Technology (VRT):** This includes farm field equipment like sprayers and planters that can accurately manage how quickly crop inputs are applied and how much tillage is done. For instance, a fertilizer applicator equipped with VRT offers a way to guarantee that fertilizer applications are done only in the quantities and areas where they are required.
- **Remote Sensors**: This apparatus creates images of the soil, crops, and the information is analyzed before being added to the GIS directory.
- In order to calculate a triangulation, fix and determine the receiver's specific location, ground receiving equipment can simultaneously receive this location data from many satellites. This is used to generate yield maps for each field.
- Software and computer gear are needed to evaluate the information acquired by yield monitors and GPS; this assistance will be presented in readable ways such as map data, graphs, or reports.

3.0 METHODS AND APPROACH

To perform precision agriculture, farmers must choose and use the appropriate technology and machinery. By choosing equipment that can be utilized with extreme precision, the farmer has already taken the first step toward establishing precision agriculture. The same is true for choices including planting, tillage, harvesting, and equipment used after harvest. In light of this framework, it is possible to think about the two stages of a full precision agricultural system: management unique to the site and control of the post-harvest procedure. Site-specific management is the field phase of the production system. Once the required technology and equipment are in place, the farmer might decide to keep maintaining the fields using a site-specific strategy. In site-specific management, the field is split into smaller grids, and choices are made depending on the requirements of each grid. Using GPS/GIS technology and variable rate equipment, inputs are applied in accordance with the needs of the grid. By treating each grid in accordance with its recommendations, chemicals and seed are kept from being excessively sprayed in places where they won't be useful. Areas that require rates can still receive them.

Consider the following use-case: to reach his field, a farmer drives a tractor that is GPS-guided. The GPS determines the exact location of the tractor in the field. It sends signals to the tractor-mounted computer with a GIS that is loaded with the soil nutrient demand map. The specific fertilizer needs for that site would be determined by the GIS in conjunction with a decision support system. The variable rate fertilizer applicator, which is once again attached to the tractor, is then instructed to apply the precise quantity of fertilizer to the precise farm site. To make things clearer, precision farming is a technique that matches the use of resources and agronomic techniques to the features of a field's soil and crop requirements. As a consequence, it suggests that nations with different levels of technical development may adopt and use precision farming.

The processes taken in precision agriculture are:

- **Field Data Collection:**
  The initial steps of site characterization and site selection for precision farming will be furnished with the aid of satellite remote sensing. This will give important knowledge on traditional land use and practices as well as the soil environment. The basic inputs for the GIS currently include information such as topography, slope and aspect, hydrology and drainage systems, land use kinds and borders, current weather and climatic conditions, and soon more. They will support the administration of a database that contains several layers of spatial data, each

of which has exact control over the location of the ground in the fields. Inputs that need to be added on top of the satellite include physically measurable layers like water content, particle size distribution, and rooting volume data that is contained within the GIS.

3.1 Data Analysis and Decision Making

As part of data manipulation, correction functions for the geometry of digital image data, including scanned satellite pictures and digital images are used. Image interpretation will become simpler as a result of improvements in both the spatial and spectral domains. A geographic information system may be used to apply the results of statistical classifiers used to categorize digital photographs in both supervised and unsupervised modes. These results include information on crop or insect infestations, soil kinds, vegetation types, and plant stress. As a clear and useful tool for controlling farm input supplies, the presentation of several pictures is used.

- **Data Management**
  GIS enables the blending of diverse datasets, which is necessary for precision farming because it requires a wide range of data from several sources. Data management will concentrate on four characteristics of the data in order to guarantee consistency across the various data sources: Management, generalization, sampling, and clarity.

4.0 PRECISION AGRICULTURE IN NIGERIA

Since the country's independence, agriculture has been crucial to Nigeria's growth, contributing to both the nation's food security and its capacity to generate revenue. The ordinary Nigerian needs to engage in this industry because a bulk of the country and its citizens depend on it. The majority of jobs, revenue, and food for the world's constantly expanding population are found in the agricultural sector, together with agro-based businesses. Nigeria as a whole still lacks the ability to produce its own agricultural goods because the majority of its food crops are outsourced or imported. Farming systems and practices in Nigeria are still very much traditional and non-scientific to a large extent. Farming systems can be described as a collection of parts connected by some forms of interaction and interdependence that work within a predetermined boundary to accomplish specific agricultural goals for the benefit of the farm's beneficiaries and all related businesses, therefore mechanization of the farming systems goes a long way to improve productivity and yield. Several governments of Nigeria have introduced different farming programmes and policies targeted at improving agricultural productivity to meet the growing demand by the population and agro-industries (Olaoye, 2014).

However, due to the fact that agricultural productivity has not kept up with the population's expanding needs, Nigeria's twin problems of agriculture and food insecurity have assumed starkly opposing stances. Two significant areas have been identified from the agrarian policies of 2016 which are the inability of products to meet the domestic demand and the failure to achieve the quality required for the foreign market (Lee *et al.,* 2012). These policies and programmes are connected to the poor farming methods employed and the lack of essential farming inputs such as fertilizer, herbicides, improved seeds, irrigation crop protection and necessary support from the various agricultural schemes (Toenniessen *et al.,* 2008). Due to industrialization and urbanization, there are drastically less farmlands and farming resources, with a rise in population expansion and a lack of agrarian support resources, the agricultural system's yield, viability, and profitability have lately become problematic. At

the moment, Nigeria is regarded as one of the world's top producers of grains (Ndukwe *et al.,* 2015) including rice, maize, sorghum, and others from Africa, hence, both the use of technology and traditional farming practices need to be enhanced. There are various challenges to the applicability of technological innovations to farming practices in Nigeria. These challenges do not only include the non-availability of the much-needed technology but many other factors which consist of; lack of electricity supply, insufficient water supply, land allocation methods to farmers, knowledge of precision agriculture among the farmers and the government policies (Mustapha *et al.,* 2012).

Precision agriculture aims to collect and evaluate data on the variability of soil and crop conditions in order to enhance the effectiveness of agricultural inputs within small areas of the farm field. To meet this efficiency objective, the field's variability must be manageable. Less fertilizer and chemical inputs are used and applied where they are required when crop inputs are used effectively. The economy and ecology will benefit from this optimization. Costs associated with the environment are challenging to estimate financially. The reduction of soil and groundwater pollution from farming activities has a desirable benefit to the farmer and to society (Gary, 2004). Information, Technology and Management are pivotal factors for the famer to grasp in order to make efficient use of precision agriculture.

4.1 PRECISION FISH FARMING (PFF)

Fish farming (aquaculture) is a form of agriculture. Aquaculture, or the farmed production of fish and shellfish, has grown rapidly, from supplying just 7 percent of fish for human consumption in 1974 to more than half in 2016, and this has led to challenges including concerns over environmental degradation, disease and parasite outbreaks, and the need to efficiently manage resources to maximize productivity (Fearghal and Jon 2020). The goal of precision fish farming is to apply engineering and technological ethics to the production of fish, thereby enhancing the farmer's capacity to oversee, effectively observe, and record biological processes in fish farms. Several strides have been made in implementing precision fish farming in different parts of the globe. A water quality monitoring system for a large aquatic area was developed using wireless sensor network technology. The system detects pH, dissolved oxygen, water temperature, and pH in a pre-programmed time interval. Results showed that the system has excellent prospects and can be used for environmental monitoring by offering interested parties with essential and timely information for sound decision making (Demetillo *et al.,* 2019). Although relatively new to technological advancements, fish farming has, in some respects, benefited from contemporary technology by adapting to challenging conditions. The next phase of industrialization is dependent on using data to inform decisions. Certain challenges exist related to its location in the ocean –requiring robust, low-cost sensors capable of underwater and in-air wireless connectivity (Fearghal and Jon 2020). However, the industry has seen huge progress in this regard with many farms being equipped with a dense network of sensors streaming data in real time. Similar to other industries, the current focus is extracting action-able insight from IoT data (IDC 2017).

Major examples of PFF technologies includes; Wireless Sensor Networks, Cloud Service Setup, mobile applications, Global Positioning System (GPS) modules, Genomics and genetic analysis, etc.

4.2 CHALLENGES OF PRECISION AGRICULTURE

In order to reduce food insecurity, poverty, sickness, and hunger in Nigeria and many other nations, study in this area has become necessary. The primary constraint of agricultural

development in Nigeria is the use of inadequate methods of data and information acquisition of agrarian land potential, crops condition and farming activities (Harris and Orr, 2014). As a result, data gathering and information for planning farms and creating policies are inaccurate. As an illustration, inadvertent land usage commonly leads to the misappropriation of precious farmland. This is a major setback for agricultural progress. It is crucial to remember that conventional approaches lead to a sizable agricultural yield. This is very dependent on procedures and the laws of nature to sustain yield and quality. The foundation for the detection, identification, measurement, and monitoring of agricultural phenomena was the presumption that features of the agricultural terrain, such as crops, farmed animals, crop infestation, and soil oddities, have recognizable markers on the form of data from remote sensing. These identifiable markers are a reflection of crop type, state of maturity, crop density, crop geometry, crop vigor, crop moisture, crop temperature, and soil moisture as well as soil temperature (Chong *et al*., 2017). Precision agriculture based on the incorporation of information and communication technologies into machinery, equipment, and sensors in agricultural production systems, allow a large volume of data, and information generated to be inputted into the automation system for processing (Rodrigues, 2013).

In order to implement productive agricultural techniques, the following challenges offered by this new technology must be overcome:

i. Precision agriculture cannot be used with all crops. A range of technical and economic factors need to be investigated and confirmed prior to adoption.
ii. For interoperability, every device has to be included into a comprehensive platform that is user-friendly for farmers.
iii. The need for local farmers to be conversant in smart agricultural practices incorporating all sensors and networking the fusion of mapping and real-time systems.
iv. Rural locations do not have many reliable, powerful connections to the internet or other networks. Computerized farming may not function effectively in isolated rural settings, particularly in developing countries. Agro-sensors and gateways require cloud services for the transmission and archival of data. Farms with mountainous terrain or tall, thick trees may also have trouble receiving GPS signals.
v. Farm size management: Depending on the soil sample process, different types of soil will be needed, with the goal of minimizing inputs and maximizing outputs. It is vital to use economic evaluation frameworks.
vi. New Hardware and Software: This precision agricultural technology depends on a wide range of complicated hardware and software, which might lead to data loss and incompatibility as well as significant energy usage. In order to process and limit the amount of data gathered, we must understand the methods that were employed.

5.0 BENEFITS OF PRECISION AGRICULTURE

i) **Risk reduction:** PA provides site-specific control at the farm level, which can detect problems with the growing environment and lower the variation of net yield. Crop rotation, variety choice, and other risk-reduction agronomic techniques may all be improved at the farm level with the use of PA data. Generating improved market judgments can also be aided by knowledge about crop development throughout the course of the season.
ii) **Excellent use of the resources:** Information on the weather and the properties of the soil may be used to plan and schedule activities, which will lead to greater rates of machinery utilization and reduced costs per acre. Additionally, GPS-based navigation systems

can aid farmers in more efficient use of field equipment in difficult terrain.

iii) **Product differentiation management:** Future agricultural productivity within a particular field may be differentiated by farmers, thanks to precision technology. For instance, you may isolate wheat with a greater protein content for marketing through more successful channels. Additionally, the technology of precision farming will make it possible to exercise the extra control needed to manage the production of differentiated commodities as opposed to traditional bulk crops. The crop conditions may be recorded, and the inputs can be managed to fulfill the crops' very particular requirements.

iv) **Ecological sustainability:** Chemical and fertilizer treatments will be more accurately planned to suit crop demands, avoiding overapplication, which may be damaging to the environment. Precision agricultural technology will support good land conservation through management strategies.

6.0 REQUIREMENTS FOR IMPLEMENTING PRECISION AGRICULTURE

Key components that can improve the implementation of PA amongst most farmers include scalability, low cost, support, integration and interoperability with the utilization of open data standards, rule-based workflows, automated and intuitive data processing methods, user control over analysis and processing functions, systems customized to meet farmer needs and an easy-to-use interface (Mustapha *et al.* 2012). Farmers need solutions that are scalable as additional PA applications become available. Low-cost methods are necessary because farmers are hesitant to take a chance on expensive applications that might not deliver the promised advantages. Application and system interfaces that can operate with past, present, and future operations are necessary for farmers. Because farming is such a varied business, PA applications must be customized to meet the unique needs of each farmer. Farmers that require PA applications can find them in specialized modules. Thanks to rule-based processes, farmers may merge their business experience into a PA application. Effective communication is ensured as regards standards and operability of the various forms of technologies. Usability and automated data processing methods help the farmer manage the large volume of data generated by PA applications (Lee *et al.,* 2014)

CONCLUSION

There are many opportunities for precision farming to be adopted, even though it is still in its infancy in Nigeria. As a result of the technology's prospects to boost yields and financial returns on fields with a lot of variability while minimizing environmental degradation, we think progressive Nigerian farmers will adopt it on a limited scale with guidance from the public and private sectors as well as agricultural associations. The early assistance from governments and the private sector is essential since precision agriculture has a lot to offer and should be fully accepted. Its economic stimulus initiatives cannot be over-emphasized.

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Health And Place Settings: Understanding The Medical Geography Of Nigerian Migrants In The Uk

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Abstract: *Drawing from discourses on the therapeutic landscapes and medical geography, the study uses malaria sickness experiences of migrants to understand the factors shaping the production, reproduction and sustenance of Nigerian ethnic and non-biomedical landscapes of healing in the UK. The results identified and characterized the spaces enhancing the circulation of the Nigerian ethnic medical products and services, mostly in the home, business, kinship, organizational/religious settings and network. The emergence of such landscapes is inevitably linked to the inability of the western medical practices and values to accommodate other non-western medical beliefs, values and practices.*

Keywords: Health, Place interaction, therapeutic landscape, Nigerian migrants, the UK
CITATION:
Akpabio, E. M. (2023). Health and Place Settings: Understanding the Medical Geography of Nigerian Migrants in the UK. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U.G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp.493-506

Introduction

The contribution of place characteristics in the variation and production of health behaviours have long formed the focus of geographical and sociological research since the 1990s (Cummins *et al*., 2007). These have been measured in terms of qualities in their material and social resources, including the availability of relevant formal and informal social resources and infrastructures (education and medical services, day-care facilities, shopping spaces, spiritual and religious institutions, social networks, etc.). Studies have already demonstrated the socio-physical aspect of place effects on health outcomes in terms of the availability and quality of infrastructures and resources (Macintyre *et al*., 2002, Bernard *et al*., 2007 and Cummins *et al*., 2002, for a review). Clearly, 'place effects' on health outcomes could manifest by either constraining or enhancing some healthful behaviours and living through its composition or contextual effects (Macintyre *et al.,* 2002, Shouls *et al*., 1996).

But 'place influence' may not operate in a 'standalone' capacity; individual characteristics could interact to reinforce specific health behaviours and outcomes. Gidden's (1984) structuration theory offers useful explanation on the dialectic interplay of structural factors and human agencies in the production of specific behavioural outcomes. In health systems and behaviours, while the structural factors (in the forms of the available material, physical and social resources) present opportunities and constraints to health practices, behaviours and outcomes; individual agencies, on the otherhand, can serve to reproduce, shape and transform specific structures through some routinized practices to suit specific ends. Studies on the production and reproduction of health, health behaviours and practices reflect, to a large extent, the dynamic relationship between structure and agency (Hampshire et al 2011, Madge 1998, Gesler 1993, Bernard et al 2007).

Debates on 'place effect' in the production of health, health behaviours and health outcome seem to be dominated with discourses on the impacts of the material and infrastructural features of places and neighbourhoods, while the socio-cultural features including shared values, norms, religious and spiritual beliefs and economic interests, are given less consideration. Along with the material/physical perspectives of a place, the socio-cultural features of individuals also shape health behaviours and practices. But how do these features play out at transnational health behaviours, which seem to expose individuals to different place contexts of health practices and orientation? This paper is more interested in understanding the health practices fostered in the context of place interaction involving migrants at transnational levels. Parson's (1937, 1951) argument that social systems build from norms and values which together with other actors make up part of the environment can help understand the formation and dynamics of medical attitudes at specific place settings, but what happens at points of interaction when an individual has to migrate between different place settings and contexts with different medical and health systems? Specifically, the study uses malaria sickness experiences to understand the diverse landscapes of non-biomedical healthcare of Nigerian migrants in the UK, as well as the factors shaping their production, reproduction and sustenance. By this, the study seeks to draw on and contribute to discourses on the therapeutic landscapes.

Overview of therapeutic landscape

In Gesler's (1993: 171, see Williams 2010: 1634) formulation, the therapeutic landscape incorporates place, settings, situations, locales, and milieu which emphasize the various roles of the physical, symbolic and social environments that work to achieve an 'enduring reputation for achieving physical, mental, and spiritual healing.' Shedding more light on this Williams (2010: 1634) observed that Gesler's model captures a number of the therapeutic landscape themes broadly categorized into two groups: 'inner/meaning' and 'outer/societal context.' The 'inner meaning' theme includes: natural setting, built environment, sense of place, symbolic landscapes and everyday activities. The 'outer/societal context' themes were defined as: beliefs and philosophies, social relations and/or inequalities, and territoriality.

The therapeutic landscape concept has expanded following some empirical and fieldwork experiences and results in contexts of diverse landscapes and landscape interaction consequent upon cross-border migration (Hampshire et.al 2011, Williams 2010, Leach et.al 2008, Dyck and Dossa 2007). Consequently, the therapeutic landscape concept has gone deeper beyond its traditional usage and emphasis on place determinant of health-seeking behaviours and healing, to incorporate the role of virtual/network spaces and the health care beliefs, practices and experiences of groups of people engaging in the processes of constructing and re-constructing the landscape of health care. According to Madge (1998), 'the therapeutic landscape is an outcome of the interplay between specific cultural practices and unequal economic and political realities' (p. 309).

While questioning the longstanding binaries/categories (public/private, biomedical/traditional therapies) that have, over the years, dominated health care analysis and policy, Leach et. al (2008) argued that a focus on the therapeutic landscape can reveal the most important dynamic elements of people's practices and experiences in their daily health care seeking behaviours. The results presented new sets of distinctions and categorizations in which people talk about and make use of (and which transcends traditional distinctions of biomedical-traditional and public-private) to include new categories as: between gendered

spaces; strength-building vs. cure; certainty or ambiguity of ailment; injection vs. oral therapies; by types of payment, and by quality. In such dynamic outcome reveals a landscape of plural health care services/therapy.

In migration context, the therapeutic landscape, can advance the understanding of how migrants'[1] notions of health and everyday health seeking behaviours interact with their destination environment to produce and reproduce new spaces of care and medical practices. Migration often imposes challenges related to the tension characterizing the differential experiences of landscapes, and how to negotiate around the challenges of new regulations, economic circumstances and survival/coping realities. These can be particularly very demanding on migrants' resources, well-being and health, but studies have not focused on how these challenges and tension have enhanced migrants abilities to reproduce old therapeutic landscapes or construct new spaces of health care and medical practices. This study intends to address this issue by focusing on the various experiences and practices for reproducing and creating new spaces of health care among Nigerians in the UK.

The Research

Overview of the study population

The Ibibio ethnic group in the UK constitutes a smaller proportion of the over 500,000 Nigerians estimated in the UK. Ascertaining the actual data was difficult. However, estimates should fall in the region of very few hundreds. The Ibibio ethnic group occupies the present Akwa Ibom State, south-south portion of Nigeria.

In the literature all the ethnic groups in Akwa Ibom State have a common ancestral origin in Ibibio given their shared characteristics, namely mutually intelligible dialect, common ancestry, traditional modes of worship and organization (Faithmann 1999, IDRC 2001, Udo 1983). The Ibibios are dominantly Christians (over 90%) but there is also a blending of some basic elements of the traditional and Christian beliefs given some tendencies for ancestral worship, libation and incantations, beliefs in witchcrafts and sorcery, among several other traditional and religious taboos and norms.

Notions of sickness

Notions of health and sickness among the Ibibios still depend on the wider traditional/indigenous Ibibio worldviews[2] of health and well-being as the product of the interaction of an individual with the wider socio-cultural and supernatural environment. Health and well-being are believed to be determined by the dynamic unity and harmony of the body, mind and soul-to the extent that sickness or ill health would automatically imply a 'discord in the social body', a 'rupture of life's harmony' or the 'activation of supernatural forces' (Good 1987: 14, cited in Madge 1998: 294); which hardly fit with the western scientific explanation of health and illness. Within this framework, three broad illness categorizations are recognizable as natural, mystical and inherited (Izugbara and Duru, undated)[3]. The Ibibios conduct their medical practices within the framework of the tradition and religious beliefs which depends on rituals, plants and other natural substances as well as spiritual exercises (fasting and prayers),

[1]The context of 'migrant' as used here broadly incorporates people who arrive at the place of destination through social networks that help them in their transition from one society to another society (Waldinger 2001: 10)

[2]Worldview according to Schlitz et. al (2010: 19) denotes the combination of beliefs, assumptions, attitudes, values and ideas to form a comprehensive model of reality, especially on how processes and events are interpreted, framed and treated.

[3] According to the authors (P.33), natural causes of sickness include drinking of unclean water, over eating, lack of rest, over indulgence in sex, ingestion of poisonous substances, exposure to inclement environment, etc. however, episodes of unwellness that defy simple remedies and cannot be immediately linked to natural causation are often attributed to the activities of the gods, ancestors, deities, and spirits. Witcrafts, errors in rituals, infraction of taboos and the neglect of deities are also listed in the realm of the mystical causes of sickness. The inherited has to do with the hereditary transfer of some illnesses from parents to their offspring. Although these categorizations draw from the Igbo (Nigeria) ethnomedical cosmology, the Ibibios share a similar worldview as the immediate and closest neighbours distinguishable mainly by language dissimilarities.

in addition to the use of the modern biomedicine in some contexts (see also Ekong 2001, 2008; Ajala and Wilson 2013).

Malaria prevalence

Malaria infection (transmitted by *plasmodium falciparium)* remains a serious risk in parts of the world with climate most favourable for its spread. The WHO groupings of global malaria risk areas mention Africa as the most endemic (with 90% of the disease incidence) relative to other regions of the world (WHO 1999). In most parts of Nigeria, Oregba *et.al*., (2005) observed that the cumulative prevalence rate for malaria infection stood at 100% between 2000 and 2005, with 10% of all child mortality directly linked to it. For the developed countries, Dobson (1989) had reported that malaria had flourished in England for several centuries, its geographical limits determined by the natural habitats of the mosquito. While intervention efforts in containing the endemicity of malaria parasite have been most successful in developed countries (Europe and America), African population still remains at high risk (Hay *et al.,* 2004). The risk level remains compounded by people's perception of the disease and a lack of effective medical capacity to address the threat posed by the disease.

Malaria, the Ibibios and the justification of the study

Among the Ibibios, for instance, the general knowledge in the aetiology and etymology of malaria, its symptoms, causation and mortality still depends on individual's perceptions linked to personal health beliefs[4], spiritual problems and individual food/health habits and lifestyles. Ajala and Wilson (2013) observed that the Ibibios hold the belief that malaria is caused by a plethora of different factors ranging from eating too much of oily foods, exposure to sunlight and witchcraft attacks. These beliefs in diverse causes of malaria opens avenues for diverse management/treatment options depending on individual health biographies, knowledge and perception, but to what extent are they reproduced in other geographical contexts?

No research has attempted to understand how the Ibibio perspectives on the general aetiology and management of malaria are consciously mobilized in creating new spaces of healing in transnational contexts of migration. This study addresses the extent of consistencies and deviations over these issues while also paying attention to the influences of the UK environment and its medical system in shaping necessary therapeutic behaviours and landscape emergence.

The study methods and ethical approval

A total of 24 migrants[5] were interviewed through a combination of structured, semi-structured and in-depth interviews while informant and follow-up discussions were helpful in addressing and clarifying sensitive issues. A large number of the respondents were tracked in London, Aberdeen and Dundee in Churches, family visits and during ethnic associational meetings facilitated through previous arrangements with few known Ibibio indigens in the Uk. While 14 respondents were interviewed in a semi-structured format, 8 were subjected to detailed and indepth interview that lasted on average between 45 and 70 hours. 7 respondents opted to send in their response by post to my Oxford residence, out of which only 3 eventually honored the promise. All interviews were

[4] Through the health belief model, health related behaviors of individuals were judged as reflecting a person's level of fear, based on level of threat perceived, and a person's expected fear-reduction potential of taking action. The health belief model places an individual within a life space scenario composed of regions, some of which were positively valued (positive valence), others of which were negatively valued (negative valence), and still others of which were relatively neutral. Within this scenario, diseases and other medical problems should naturally occupy the negative valence, which is expected to exert a force that move a person away from that region, unless doing so would require him to enter a region of even greater negative valence. In medical health system, the model presupposes that individual daily health behaviors were controlled by 'pull' positive forces and 'push' negative forces (see Rosenstock 1966)

[5] These exclude special Skype interaction I had with 3 individuals who had previously spent several years in the UK.

conducted in the Ibibio language. Overlapping responses were common given that malaria sickness was discussed with its associated symptoms.

Several issues bordering on the Ibibio perspectives on malaria sickness, its causation and treatment practices (Ajala and Wilson 2013) were discussed with the respondents to understand their dynamics (in terms of what have changed or persisted and why?) within a transnational context. The results of the interview were eventually coded and relationally classified on the basis of socio-demographic and economic characteristics as well as commonalities or differences in responses as related to specific sets of questions/narratives. Given the very small number of the Ibibios identified, every adult (from 18 years) was automatically accepted for participation provided there was willingness and interest.

The relevant ethical documentation and approval for this study was secured at the Kyoto University (Japan) and the University of Oxford (UK) before the actual fieldwork. During the fieldwork process, all ethical concerns related to anonymity, confidentiality, informed consent and the ability to withdraw from participation were thoroughly addressed.

Study Limitations

This study has several limitations which are hereby acknowledged. One, a fraction of data from a single and small ethnic group (the Ibibios) in the UK alone would not adequately generalize for a multi-ethnic Nigeria. While this study focused on comparing the health experiences and behaviours of the Ibibios within the context of transnational migration, no direct and similar fieldwork was organized for migrants' kiths and kins resident in Nigeria as far as this topic is concern. This gap was however bridged by the relevant fieldwork experiences of the author (an Ibibio indigen) in addition to the numerous secondary literatures addressing this issue (Ajala and Wilson 2013, Akpabio 2012, IDRC 2001, Udo 1983).

Two, this fieldwork was not designed to include the UK public health/medical institutions beyond few information from the secondary sources (see Krause 2014). As the health/medical experiences of migrants take place within the contexts and influences of the UK medical landscape and environment, findings from this study cannot be said to be truly objective without some inputs from the relevant UK public health institutions.

Finally, several fieldwork challenges including difficulties in tracking down busy respondents, unwillingness to disclose vital information and some inconsistencies in some information provided by most respondents were encountered. These were addressed through persistent follow-up discussions in the evening/night hours, associational meeting places, weekend visits and telephone discussions, in addition to the services of three informants who helped in tracing some willing participants while also serving to clarify or reconcile some cases of inconsistencies and irregularities in information supplied by some respondents. Despite these limitations, this study clearly lays a foundation for future research.

Results

On Types of Sickness

Malaria emerged as the common sickness discussed by the respondents with their popular local names as *uto-enyin* and *utuo-enyin ekpo*, with the former exhibiting simple and mild fever (*ufiop idem*) and the later becoming severer (acute form of malaria) or *utuoenyin ekpo*[6]. A

[6] *utuoenyin ekpo* is a situation where the feverish smptom becomes severer prompting beliefs in the spiritual attack. *utuoenyin ekpo* is an Ibibio terminology directly translated as ghostly malaria (malaria caused by ghost). Ajala and Wilson (2013) observed that *utuo-enyin ekpo* in the Ibibio belief arises when a particular episode of malaria is suspected to have gone beyond the ordinary, sensible sphere. The authors argued that although *utuo-enyin ekpo* is used biomedically to refer to typhoid fever, the local belief is that typhoid is a more acute form of malaria that is caused either by spiritual attack, by one's enemies or as a punishment for wrong doing.

range of other symptoms were associated with malaria attack including headache (*ubiak iwot*), bodily pains (*mbiaak idem*), loss of appetite and stomach disorders (*udehe idip*) depending on individual health histories and experiences.

Stomach disorder (intestinal congestion) directly translated in Ibibio as dirty stomach (*udehe idib*) is explained through sub-symptoms as vomiting, loss of appetite and general discomfort of the body. Almost all the symptoms indicated and discussed were summarized and classified as malaria. Regular mention of malaria or its association with other sickness types despite a change of the environment probably may have to do with the psychology and feelings surrounding the symptoms of certain sickness patterns which have formed part of individual cumulative health histories and experiences.

Only 22 respondents were particular about malaria (either by direct or indirect reference to it), 8 added diarrhea and stomach ache respectively as their main sicknesses; one respondent each mentioned dysentery and typhoid while 5 indicated vomiting. About 10 respondents did not mention additional sickness types besides malaria.

On the morbidity and mortality rates associated with malaria, 21 of the interviewees agreed the rate is disproportionately very higher in their home country than the UK. However, none of the respondents could volunteer information on any suspected case of malaria related mortality in the UK. As one of the respondents in his early 50s observed: '*though we do suffer occasionally from malaria, it has not been as serious as the experiences back home.*' This probably and obviously has to do with differences in the therapeutic qualities of the two landscapes especially given that the Nigerian home is very much associated with relatively poor sanitation, poor health care system and infrastructure and poor socio-economic characteristics which account for considerable health risk relative to the UK.

From the diverse accounts of the respondents, knowledge and the perception of malaria symptoms varied depending on individual's unique health histories, perception and experiences. As a respondent in her late 40s (who arrived the UK in 2006) observed:

'…I know myself…once it is its time [malaria sickness], I will know through how I feel…we do not have any major sickness here other than the same malaria…'

However, when her attention was drawn to the non-existence of mosquito in the UK, she responded as follows:

'…who tells you there is no mosquito…there are places you go and you would be surprised at the type of mosquitoes…we do not have it here…but I know the only sickness we have in our family is malaria…'

Knowledge of malaria was not necessarily related to the contact with mosquitoes-the popular malaria causing parasites. Food types, eating habits, inability to rest and spiritual attacks were associated implicitly or explicitly with malaria attack. Overeating especially of specific food types (e.g., *eba*-a popular cassava product) or too much of oily and sweet foods, eating too much of orange, drinking too much of alchol (e.g., beer product), overwork and a lack of rest, etc, were linked with malaria sickness.

References to spiritual or witchcraft attack proceed in cases of severity, complications and prolongation of symptoms. General feelings of uneasiness, sleepiness or heaviness in the stomach and loss of appetite are early perceived signs of malaria attack. At that point decisions to drain the intestine or regulate the diet are initiated. Some respondents may depend on signs of fever, general bodily pains or headache. Still some others depend on the colour of urine or the eyes. Some parents observe deviations in the general behaviours of their children to draw conclusions. These symptoms were highly varied and depended on individual health histories and biographies.

Most respondents believed the UK National health service seems not sufficiently equipped for treating malaria sickness beyond quarantine and some medical testing. This renders the possibility of patronizing the system or reporting cases very low. The fear of being quarantined was the major reason raised for not reporting perceived malaria sickness. Being quarantined for malaria automatically translates to loss of working hours and means of livelihoods and could lead to repatriation especially for those with irregular documents. The fear of quarantine is also linked to possible stigmatization in case the information is leaked to their family members and kiths and kins. The experience of a respondent in his late 30s in a medical case involving his wife helps to generate much insight as follows:

'…my wife had a minor fever and decided to visit her Physician…on interview, my wife mentioned she had travelled to Africa of recent…but the Physician started being panicked and decided to call emergency service for ambulance to carry her for specialist diagnosis/treatment…my wife was very angry on learning her Physician had called for an ambulance…she queried that her sickness was not that serious to have called an ambulance…and should call them back not to come as she was capable of going there by herself…'

The physician was panicky because of the fear that the patient must have contracted malaria during her travel to Africa, while the stigma and perceived negative omen[7] associated with being ferried in an ambulance was responsible for the woman's decision to go by herself. Narrating the experience further, the respondent said:

'…my wife was quarantined for almost a full day with all necessary blood tests…I made several calls to make sure she was released but to no avail until I went there myself…and upon certification that my wife was malaria-free, they released her…we did not know otherwise we would not have mentioned such a thing as this people are afraid of malaria…'

Another narrative from a female respondent in her late 40s went in the same tone as follows:

'…ah, you do not dare mention malaria here.o…they would isolate you…I do not know why they are afraid of malaria which carries less harm than some big and very serious diseases such as cancer which are very common here…if you look for malaria treatment, there are people who secretly deal in such tablets…or the kind of herbs you want…but they only release the tablets or injection on proper identification…'

Emerging therapeutic landscapes of malaria

Where and how do the respondents treat malaria and associated symptoms? Most respondents' knowledge of malaria and treatment practices follow established routines and habits mostly grounded in cultural perception and spiritual beliefs, as they were equally influenced by individual socio-economic circumstances and the UK environment (regulatory and institutional factors). Being equipped for the necessary adaptation in their new environment depends on being able to gain access to necessary health care information, services and products as well as secure appropriate spaces for performing, adapting and reproducing necessary health care routines, habits and healing practices. The home, business and religious settings, ethnic association and the social media emerged as important therapeutic landscapes to cater for the needs of migrants. The production, reproduction and popularity of these landscapes, in many ways, are attributed to the inability of the UK medical system and regulatory environment to accommodate the non-western medical beliefs, values and practices encapsulated in the Ibibio medical

[7] Among the Ibibios generally, the mention of an ambulance suggests a potentially 'bad omen', which explains why the woman opted not to be ferried through the ambulance service.

worldview of malaria. In this context, the 'agency-structure' interaction framework becomes important in explaining how migrants consciously mobilize their agencies in an effort to navigate their health practices in the context of their transnational experiences (Lee et.al, 2010). Below are some emerging therapeutic landscapes.

The home

The home, which serves as the domestic space for migrants and the family, primarily represents the basic spatial unit of social relations, where feelings of belonging and attachment serves to strengthen cultural and symbolic values and identity among families, friends and ethnic kiths and kins. According to Wiles (2008: in Lee et.al, 2010: 109): 'the meanings of home arguably become more complex and multi-dimensional in the context of transnational migration, and are central to migrants' lives. The home becomes the first landscape for discussing, diagnosing and treating perceived malaria sickness and symptoms. About 16 of the respondents depended on a range of self-management methods, including self-treatment, self-medication, use of herbal products, food choices and regulations and some spiritual exercises (fasting, prayers and reading of the Holy Bible). These practices are primarily conducted within the 'home space'.

The narrative of one migrant (in her early 30s) who is married to a British on how she manages herself in such context was very interesting as follows:

'…I no dey for that [implying she does not subscribe to western biomedicine]…when I am sick, I run to the nearby bush and select some leaves for [enema]…that is how I was brought up…'

She went on to recount how she transfers same health care experience in taking care of her two years old son when he is sick:

'…my husband most times sit and watch me with surprise how I handle my son the way I learnt from my parents…I hardly go to the hospital or visit a Physician…'

Earlier experiences of health care and child upbringing (acquired from the parents and society) are important health care resources still retained and reproduced in the UK.

Food types and habits were clearly linked to health dynamics as most respondents believed their health resilience and strength, to a large extent, depend on the type of food they eat. This argument was always placed in comparative contexts with the West. Careful selection of cooking condiments especially leafy materials are important. Some bitter leafs (*etidot, editan, dogonyaro*, etc) are credited with some therapeutic and medicinal values against malaria and other illnesses, when taken raw with water or cooked in a soup. In some cases, they are used for *enema* (intestinal draining). The respondents still believe they are healthier, stronger and less susceptible to most health problems as compared with the situation with the white population (the West). One woman explained why she encourages and even makes it a point of responsibility to persuade their children into eating indigenous food as follows:

'…I persuade them every day and encourage them to eat our indigenous food instead of pizza, burger or some of these western food all the times…they can lead to some unexpected problems which we may not be able to manage…'

While most indigenous foods were associated with therapeutic values, generational adaptation to such food habits and culture seems a bit of a problem to migrant parents in the UK. However, the platform of the home emerged as one important site for regulating diets and encouraging what the respondents believe is healthy living. It serves as the primary space for keeping, processing and consuming indigenous food items, health products and services as well as processing and transmitting necessary health information for the benefit of the family

members. When parents discourage their children from over dependence on western foods and products, they also provide spaces for familiarity with indigenous food and health products. Most respondents during interview were able to point to stocks of indigenous food items and products in their kitchens, some of which are available in some designated shops (African shops) while others are traded in secret.

Religious settings

All the respondents interviewed sustain and maintain well-established spiritual relationship/affiliations with the Church, the Pastors and Priests. London and other major cities in the UK have played host to major churches and spiritual centres mostly founded and patronized by a large number of migrants from West Africa. Krause (2014: 40) specifically wrote about African Pentecostalism as follows: 'the promise of healing through the power of the Holy spirit makes these strands of Christianity, especially successful in areas of the world that are characterized by extreme economic stratification and political tensions, and that is also the sending regions of migrants to the global north. The Church and other spiritual places have been known to respond to a broad range of migrants' needs, including physical sickness, immigration issues, family problems and economic difficulties.

The spiritual angle to malaria treatment is mostly considered when a specific symptom has transformed into a form popularly tagged as *idoho nkana* (not normal or beyond the ordinary). It may not specifically be *utuo-enyin ekpo* to qualify as abnormal or beyond the ordinary; other forms include *atuatuak* (severe form of shivering resulting in convulsion especially in children) or any perceived malaria symptoms that cannot be handled by the usual self-treatment, self-medication or self-management will mostly trigger a suspicion of spiritual attacks. This necessitate a range of spiritual initiatives including a visit to Pastors and religious Priests for special healing through prayers, fasting, deliverance, reading/recitation of verses in the Holy Bible, counseling, laying of hands on the sick, the use of holy water or special perfumes, etc. Familiar references such as *'Abasi akpeme owo'*, *Abasi Iyakka idongo udongo'* (English translations: God is the only one that protects us; God does not permit sickness in our midst) emphasize the broder notions of supernatural influences on health. It equally implies that the respondents had rarely incurred sickness of very serious category while in the UK.

Several Nigerian popular Pentecostal Churches have their Centres in the UK, including the popular ones as the Fountain of Love (Redeemed Christian Church of God), Christ Embassy, Kingsway International Christian Centre, Winners Chapel International, etc. There are other network of small groups of Christian worshippers who operate in private houses or rented public spaces, all attracting thousands of worshippers. Given that about 60% of the respondents claimed their health care habits and beliefs have not experienced significant change while in the UK, the proliferation of religious and spiritual spaces (especially of the Pentecostal brand) should not be surprising. The capacity and flexibility to receive and address all forms of sickness concerns from the migrants without discrimination or misunderstanding builds mutual confidence and trust between the parties. Such relationship has helped to encourage the reproduction of local values and medical idioms in a transnational context, thus justifying Robbins' (2004) assertion of the Pentecostal form of Christianity as representing one of the successful models of cultural globalization.

Business places and networks of business transactions

Several business spaces or network of businesses specializing in the importation, distribution and sales of some medical products

and food substances serve to reproduce and guarantee the delivery of ethnic products to migrants. Specialized African and Nigerian shops, network of business dealings and the open markets offer both formal and informal spaces and platforms for all categories of transactions in African products including food and drink items, special African type bathing substances (e.g., soap), herbs, roots, lotions and some popular biomedical substances (e.g., chloroquine, fansidar, etc). Most respondents seem not quite open and comfortable with the western medical and health care culture probably due to their health beliefs, socio-demographic factors and health care experiences. A male respondent in his late 40s argued thus:

'…most of us here still believe what we have works well than what is available here [i.e., the western Medicare]…if someone is sick, he or she would first explore all possible familiar and known avenues of cure…including putting salts in water to drink…he would delay going to hospital, if he ever had that option in mind…in fact he does not have much faith the hospital would solve the problem…'

For migrants with familiar experiences of malaria sickness and treatment histories, living in the UK seems most challenging especially for the newly arrived:

'…for me, we have learned to live here…when we came newly, our major problem was malaria…now I can stay up to two years without treating malaria except when I travel home…', said a female respondent in her late 40s who arrived the UK in 2002.

She went on to state how she procures some anti-malaria substances:

…if you look for malaria treatment, there are people who secretly deal in such tablets…or the kind of herbs you want…but they only release them on proper identification…'

The identification system varies depending on a particular dealer. However, it could be in forms of numbers, specific local names or some symbols, the purpose being to protect the business and the dealers. In the word of the respondent: *'…if you are caught…that is your problem…'*

Factors encouraging the proliferation of business spaces and networks to support the medical needs of the migrants could vary from high demands for specific products, migration challenges, socio-economic and cultural reasons. Migrants with irregular papers naturally would have no other place for medical attention than to be integrated in the network of informal dealers and users through the agencies of friends, aquaintainces and kiths and kins. Economic reasons were important as most migrants are so much interested in livelihood pursuits and regular remittances than engage in the luxury of regularly visiting the General Physician on the slightest case of sickness. More so, most respondents' health care culture remains poor. Back in their country of origin, many were not exposed or used to the culture of consulting physicians, doctors, booking appointments as well as taking minor sicknesses with seriousness, etc prior to migration into the UK. Visiting the clinic for most migrants used to be in the context of emergency (at a dieing point which would necessitate being forced by relatives to a treatment centre), especially given the usual stigmatization that are often held of people with frequent sicknesses and regular visits to the hospital.

Also, the beliefs in the supernatural causes of malaria implies that treatment and healing seeking behaviours can hardly be conducted within the western system of medical care with emphasis on objective medical evidence. In such context, Weisz (1972: 331) had argued that the attitude of the patient and the western doctor may conflict to the extent that: *' an explanation, no matter how truthful, which is too complex to understand, which conflicts sharply with the patient's own ideas or which seems to indict the*

patient for ignorance or superstition, may result in emotional disturbance or termination of treatment'. Ssekamwa (1967) had described the secrecy with which some members of Kampala's educational and social elite, fearful that their peers will think them ignorant or unchristian, slip under the cover of darkness into the medicine man's house of treatment. Similar findings have earlier been documented among the Ibibios (Akpabio 2012).

Multiple medical pathways to malaria treatment was equally emphasized by the respondents depending on judgment of potency, shared values and cost-effectiveness. The Indian, Chinese or other ethnic medical products were mentioned in some cases. Drawing on multiple medical pathways for instance, probably has to do with insufficient supplies of known and familiar indigenous medical products, information, exposure and education about the efficacy of alternative therapies and the calculation of the relative cost and benefits associated with specific treatment alternatives.

Associational network and the social media

Associational network and the social media constitute another therapeutic landscape for health seeking and healing behaviours for the Ibibio migrants. Several ethnic associations were tracked, including the largest umbrella body-Akwa Ibom State Association (*Mboho Ndito Akwa Ibom*) and other sub-groups such as the Mboho Mkparawa Ibibio, Itai Afe Annang, etc. These groups are funded through membership contribution as well as major financial supports from the home government or voluntary donations. They hold monthly meetings to welcome and interact with members, discuss welfare issues, organize cultural events and show solidarities with needy members in the UK. They use array of communication tools including the social media and the telephones to keep members informed and regularly updated on issues as diverse as the UK immigration laws, home affairs, coping strategies, social events involving members, business channels/products, and many other issues.

It is through these platforms that members report medical challenges, seek and obtain help/assistance, exchange information and ideas, introduce and market products and services, liaise with home, especially through travelling members, share health experiences, etc. The researcher was able to participate in some of their meetings and gained some knowledge about this study. At the meeting, everyone spoke the local language, though minutes were recorded in English. Such solidarity remarks as '*ndo eyen Akwa Ibom*, *ndo eyen Ibibio'* (proudly Akwa Ibom and Ibibio, etc) were demonstrations of cultural solidarities and emphasis on their value systems. When the topic was discussed, one male respondent in his late 30s had this to say: *'….here in London, anything you want you would find them…we help you to get what you want…'* All information, products and services relating to malaria treatment are available through these networks.

The social media have helped most migrants to stay in touch with kith and kins. Some migrants draw on the experiences and knowledge of their parents, siblings and other relatives through the social media when confronted with strange or complicated malaria symptoms that seem to defy self-management. The Facebook is most commonly used to stay in touch in matters of prayer requests, some special rituals and prescriptions on how to respond to particular cases.

Discussion and concluding remarks

Migrants negotiate everyday malaria care on the basis of past experiences, symptoms histories, perceptions, beliefs, economic interests, migration status, kinship network and social habits within the contexts of familiar, traditional and sometimes hybrid landscapes of care: the domestic, religious and spiritual, business and virtual spaces, etc. These spaces and network of spaces provide opportunities of social

interaction and adaptation within the transnational context of migration. They constitute important and dynamic settings, for discussing treatment options, accessing and evaluating information and potencies of specific malaria products, seeking for alternative therapies within the constraints of socio-demographic and economic circumstances.

From the various narratives, the interplay of a range of dynamic environmental, social, economic, cultural and institutional factors within the UK medical landscape provide the enabling condition for the emergence of new spaces for negotiating malaria care practices among the respondents. Migrants have to find ways of skillfully adapting to a new medical environment that hardly accommodate or take account of their beliefs, values and practices. Such adaptation is possible by the constant processes of producing, reproducing, sustaining and improving on their indigenous medical system and values. This fits with Bourdieu's (1979/1999) argument that power is constantly produced and an outcome of social interactions manifest in the permanent dialectic interplay between the structuring structure and the structured structure. According to Mielke et al (2011), 'this interplay of a pronounced political nature, i.e., institutionalized practices and the resulting relations are not only to be seen as the embodiment of knowledge, experiences and the history of a society, the relations as such are crystallized power'.

The UK medical institutions are a crystallized form of the UK medical power, while its ideology and practices emphasizing the biomedical care, expert knowledge and certification, in addition to some regulatory practices imply that all other medical systems and pathways to health care carry less scope for operation. For instance, the rules which render migrants, whose status are not appropriately recognized by the UK law, automatically ineligible for the NHS services increases the propensity and incentives to create new spaces or patronize other forms of alternatives within the contexts of their medical worldviews.

In migration setting, this paper conceptualizes medical worldview dynamism of an individual as a process actively mediated by cross-cultural experiences whereby individual's initial unified sets of medical values and preferences at primary place of socialization are brought in a direct and frequent encounter with completely different but opposite sets of experiences and societal norms. Drawing from some psychology and anthropology literatures, this paper argues that the potential for medical worldview change or transition at that points of encounter depends on individual's critical self-evaluation or reassessment of the effectiveness or otherwise of a specific medical system among the contending ones (see Fank and Fank, 1991, Leach et al, 2008). This probably partly accounts for the plural medical landscapes drawn upon for malaria healing.

In conclusion, this study is largely exploratory and generalization of results may not be very appropriate at this stage given the small sample size and short duration of interaction. It is also important to state that using malaria sickness alone may not sufficiently capture the diversities and nuances of health beliefs and healthcare practices given that individual beliefs, attitudes and related behaviours may vary between sickness types including new forms of sickness that are outside the scope of individual health biographies and past experiences especially in a transnational context. Future research could address some of these gaps as well as focus on building long term ethnographic data of the Ibibio health-seeking behaviours in the UK.

Acknowledgements

The Japanese Society for the Promotion of Science (JSPS) funded this study, while the Universities of Kyoto and Oxford provided the platforms for this research. I really thank Prof

David Pratten (St Anthony's College, Oxford) for assistance during fieldwork. I acknowledge the immense contribution of Professor Kaoru Takara (DPRI, Kyoto University, Japan) who provided the platform for hosting this project as well as other forms of assistance. My gratitude to the following for efforts and assistance: Mr and Mrs EM Nsek, Ndidi Nicholas and Jude Obidigwu. I acknowledge the tremendous cooperation of the Akwa Ibom Indigenes in London on whose platform (through its monthly meeting on the 26th July, 2014) I was able to reach out to several members. Although the JSPS funded this study, the ideas expressed in this paper are of the author's and not of the JSPS.

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Ethical Hacking & Cybercrime Security In Nigeria

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Abstract: *The explosion of internet access in Nigeria is of prime concern for both policymakers and key players in the world of cyber security, as vulnerability in the Nigerian context is always imminent. Within the context of national security, it has been suggested that the major focus of the Nigerian security apparatus should pivot toward a non-traditional approach based on cyber security and intelligence gathering to address nontraditional/nonmilitary threats. Yet, comprehensive analysis of Nigerian cyber security issues is grossly inadequate, a gap this article seeks to address. This study therefore attempts an overview of cybercrime and identified the causes of Cybercrime in Nigeria. It critically analyzed Ethical hacking as a means of providing security to cybercrime and the various threats posed by unethical attacks on computer systems and network devices. The paper recommends identifiable measures that Nigerians should adopt to strengthen its cyberspace to prevent cyber attack and promote national security.*

Keywords: Cybercrime, hacking, ethical, cyber security, vulnerability, Nigeria.

CITATION:

Ebong, V. O. (2023). Ethical Hacking and Cybercrime Security in Nigeria. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 486-492

Introduction

Cyber security in particular poses an unrelenting challenge, threatening the existence of mankind and infrastructures across nation-states. Countries are making serious efforts in protecting their cyberspace from cyber attacks and cybercrimes in the face of threats and vulnerabilities that could cause billions of dollars' worth of loss in properties, cash theft, and the collapse of critical national infrastructures (Fischer 2009). Over the past decade, the internet has experienced an explosive growth with the number of hosts connected to the internet increasing daily at an exponential rate. As the internet grows to become more accessible and more services become reliant on it for their daily operation, so does the threat landscape.

Nigerians have become cyber-creatures, spending a significant amount of time online. As the digital world expands, so does cybercrime in Nigeria. According to Check Point, a global network cyber security vendor, as of 2016, Nigeria is ranked 16th highest country in cyber-attacks vulnerabilities in Africa (Ewepu, 2016). Nigerians are known both home and abroad to be rampant perpetuators of cybercrimes. The numbers of Nigerians caught for duplicitous activities carried by broadcasting stations are much more in comparison to other citizens of different countries. The contribution of the internet to the development of Nigeria has had a positive impact on various sectors of the country. However, these sectors such as the banking, e-commerce and educational sector battles with the effect of cybercrimes. More cybercrimes are arising at an alarming rate with each subsequent crime more advanced than its predecessor (Omodunbi *et al.,* 2016).

Cyber Security, also known as computer security therefore becomes a necessity in an attempt to maintain and monitor the computer system to prevent a cyber attack. Cyber security is defined as the protection of computer systems from theft or damage to the hardwares, softwares or electronic data as well as from disruption or misdirection of the services they provide (Sule *et al.,* 2021). Recently, several internet assisted crimes known as cybercrimes are committed daily in various forms such as fraudulent electronic mails, pornography, identity theft, hacking, cyber harassment, spamming, Automated Teller Machine spoofing, piracy and phishing.

The general objective of this paper is the critically examine the role of ethical hacking in providing security to cybercrime in Nigeria. Specifically this paper seeks to:

i) Conduct an overview of cybercrime and identified the causes of Cybercrime in Nigeria.
ii) Critically analyzed Ethical hacking as a means of providing security to cybercrime
iii) Examine the various threats posed by unethical attacks on computer systems and network devices in Nigeria.
iv) Recommend appropriate measures to prevent cyber attack (cybercrime) in an attempt to strengthening Nigeria cyberspace and promote national security.

Overview of Cybercrime

Cybercrime is a type of crime that takes place in cyberspace, or in the realm of computers and the Internet. Because our society is evolving towards an information society where communication occurs in cyberspace, cybercrime is now a global phenomenon. Cybercrime has the potential to significantly influence our lives, society, and economy. According to Kevin G. Coleman *et al* (2014), Cybercrime is defined as "The premeditated use of disruptive activities, or the threat thereof, against computers and/or networks, with the intention to cause harm or further social, ideological, religious, political or similar objectives or to intimidate any person in furtherance of such objectives."

Cybercrime is a new trend that is gradually growing as the internet continues to penetrate every sector of our society and no one can predict its future. The crime usually requires a hectic task to trace.

Categorizes Cybercrime in Nigeria

Uba, Josephine and Olisa Agbakoba (2021) Categorizes Cybercrime in Nigeria into:

1. ***Cybercrimes against People*:**
   Cybercrimes against people include cyber harassment and stalking, e-mail phishing, dissemination of obscene material, such as pornography and indecent exposure, various sorts of spoofing, credit card fraud, human trafficking, identity theft, and online connected libel or slander. The potential harm to humanity from such a crime cannot be overstated. If not managed, this is one cybercrime that threatens to impair the progress of the younger generation as well as leave irreparable scars and injuries.

2. Cybercrime against property

The type of cybercrime is cybercrime against all types of property. Distributed Denial of Service (DDoS) attacks, hacking, virus transmission, cyber and typo-squatting, computer vandalism, copyright infringement, and Intellectual Property Right (IPR) breaches are examples of these crimes.

3. Cybercrime against the Government:

When a cybercrime is committed against the government, it is considered an attack on the sovereignty of a nation and an act of war. Hacking, gaining access to confidential information, cyber warfare, cyber terrorism, and the use of pirated software are all examples of cybercrime against the Government. The expansion of the Internet has revealed that the

channel of Cyberspace is being used by people and groups to threaten foreign governments as well as intimidate a country's citizens. When an individual hacks into a government or military-run website, the offense becomes terrorism.

Causes of Cybercrimes in Nigeria

The following are some of the identified causes of cybercrime (Hassan *et al*, 2012)

i) Unemployment is one of the major causes of Cybercrime in Nigeria. It is a known fact that over 20 million graduates in the country do not have gainful employment. This has automatically increased the rate at which they take part in criminal activities for their survival.

ii) Quest for Wealth is another cause of cybercrime in Nigeria. Youths of nowadays are very greedy, they are not ready to start small hence they strive to level up with their rich counterparts by engaging in cybercrimes.

iii) Lack of strong Cyber Crime Laws also encourages the perpetrators to commit more crime knowing that they can always go uncaught. There is need for our government to come up with stronger laws and be able to enforce such laws so that criminals will not go unpunished.

iv) Incompetent security on personal computers. Some personal computers do not have proper or competent security controls, it is prone to criminal activities hence the information on it can be stolen.

v) Urbanization. This the processes by which towns and cities are formed and become larger as more and more people begin living and working in the central area. Urbanization establishes such institutions as the banking, e-commerce and educational sector that end up battling with the effect of cybercrimes.

Cyber Hacking

The word "Hacking" term refers to the hobby/profession of working with computers. It is describe the rapid existing software to make code better and efficient. Professionals working in the cyber security field are known as Hackers. Sharma, *et al* (2015); Rathore & Chana (2013) and Rathore (2015) variously identified two types of Hacking- Ethical hacking and Unethical hacking

1 Ethical Hacking:

This is also known as "White Hat Hacking" and defines the practice of breaking into computers without malicious intent, simply to find security hazards and report them to the people responsible. Ethical hacker refers to security professional who apply their hacking skills for defensive purpose and constructive purpose with due authorization.

2 Unethical Hacking:

Unethical Hacking, on the other hand, is "cracking". Cracking activities is breaking the computer security without authorization or uses technology, or tools (usually weak links of a computer, phone system or network) for vandalism, credit card fraud, identity theft, piracy, or other types of illegal activity. So, cracker is refers to person who uses hacking skills or computer system knowledge in offensive purpose and therefore criminals.

3 Importance/Roles of Ethical Hacking

Roles of ethical Hacking are following:

- Evaluate the Weak links of network and computer system
- Find out the malicious contents from the network traffic.
- Trace out the cyber culprits by using some tools and tracing tools etc.
- Shut down all the doors of network and operating system and information system for security pirates.
- Ethical hacker work as security advisor of network and computer system.
- Diagnose the security threat of the system.

- Restricts the unauthorized access of network or system by installing advanced security or IDS system.
- Protect the information system or network from Penetrating Testing.

Major Threats of Unethical Hacking

Unethical hacking is cybercrime and being use as prominent arm to make crime and cause millions harm every day. To secure a computer system, it is important to understand the attack that can be made against it and these threats can be classified among others, into one of these categories below: (Omodunbi et al 2016; Michael, Boniface & Olumide 2014 and Paul 2010).

Virus attack: The damage is done not only to a person but to the masses is the case of the Melissa virus. The Melissa virus first appeared on the internet in March of 1999. It spread rapidly throughout computer systems in the United States and Europe. It is estimated that the virus caused 80 million dollars in damages to computers worldwide

Spoofing: This the act of masquerading as a valid entity through falsification of data such as username, MAC or IP address in order to gain access to information or resources that one is otherwise unauthorized to obtain.

Phishing: Phishing is simply the theft of an identity. It involves stealing personal information such as username, password, credit card, account details directly from unsuspecting users. It is also an act of fraud against the authentic, authorized businesses and financial institutions that are victimized. Phishing has become one of the fastest growing cybercrimes in Nigeria and is mostly carried out on bank customers. Fraudsters have devised a means to mimic authorized organizations and retrieve confidential information from clients. It is typically carried out by email spoofing or instant messaging directing the user to enter details at a fake website whose look is almost identical to the legitimate one.

Denial-of-service (DoS) attacks: These are designed to make a machine or network resources unavailable to its intended users. Attackers can deny service to individual victims, such as by deliberately entering a wrong password enough consecutive times to cause the victim account to be locked or they may overload the capacity of a machine or network and blocked all users at once.

Backdoor: Backdoor in computer system, a cryptosystem or an algorithm is any secret method of bypassing normal authentication or security controls. They may exist for a number of reasons, including by original design or from poor configuration. They may have been added by an authorized party to allow some legitimate access or by an attacker for malicious reasons; but regardless of the motives for their existence, they create vulnerability.

Demolition: Most cruel face of this unethical hacking, are hack the account, identity, penetrating in unauthorized network or system and sniffing the data etc not only for money but also spread terrorism. Demolition is example of such kind of hacking which shocked the whole world and challenged the USA network security. In this terrorist attack, all information are transfer over network using new technique stenography through which all the encoded textual information was hidden into funny image by advanced programme.

Privilege Escalation: This describes a situation where attackers with some level of restricted access is able to, without authorization, fool the user into giving them access to restricted data or have unrestricted access t a system.

Social Awareness and Precaution During Net Surfing

- Should not click any hyperlink if you are not sure about the link

- Should not create unnecessarily many email account.
- Should not use anonymous user ID and password for net surfing (ie looking for information or other interested things in the internet.
- System should be password protected and should automatically lock when system is idle for long time. Such password should be strong with letters, numbers and special characters enough to confuse the hackers/attackers.
- Destroy all the important material related to system, network, or id so that dumpster diving cannot be done.
- User ID and password should be strong with special characters and should be change periodically.
- We should not provide your personal information unnecessarily to unknown sites or we are not sure about sites credibility.
- Use encryption and digital signature etc. techniques to transfer the important data.
- We should always avoid checking unknown greetings, downloading screen saver, free software.
- We should avoid to uses of pirated software.
- Vendor-supplied software should be free from bugs (unexpected defect, fault or imperfection), missing operating system patches, vulnerable services, and insecure choices for default configurations. (Semeria, 2010; Rathore, 2015; and Omodunbi, *et al.*, 2016).

Measures for Network Security

The state of computer security is conceptual ideal, attained by the use of the three processes: threat detection, prevention and response. Hassan, *et al* 2012; Omodunbi, Odiase and Esan 2016 and Rathore, 2015 variously identified some security measures to include the following:

6.1 Intrusion Detection Systems (IDS):

An IDS monitors network traffic and monitors for suspicious activity and alerts the system or network administrator. IDS may also respond to anomalous or malicious traffic by taking action such as blocking the user or source IP address from accessing the network. There are Network based (NIDS) and Host based (HIDS) Intrusion Detection Systems. Host Intrusion Detections Systems (HIDS) are run
on individual hosts or devices on the network and Network Intrusion Detection systems (NIDS) are placed at a strategic point within the network to monitor traffic to and from all devices on the network.

6.2 Firewall:

A firewall is a system that is set up to control traffic flow between two networks. Firewall is effective means of protecting network system from the threats and a single choke point that keeps unauthorized user out of the protected network and prohibits potentially vulnerable services from entering and leaving the services.

6.3 Port Scanning:

A port scanner is a program which attempts to determine a list of or range of open TCP, UDP, etc. ports on a list or range of IP addresses. Port scanners are used for network mapping and for network security assessments. So, we have knowledge to disable (close) all doors (port) to prohibit the pirates to enter in network.

6.4 IPSec:

IPSec is a protocol suite which is used to secure communication at the network layer between two peers. When end-to-end security is required, it is recommended that additional security mechanisms such as IPSec or TLS, be used inside the tunnel, in addition to L2TP tunnel security.

6.5 ISAKMP:

Internet Security Association and Key Management Protocol (ISAKMP) is a "protocol" for establishing Security Associations (SA) and

cryptographic keys in an Internet environment. ISAKMP defines the procedures for authenticating a communicating peer, creation and management of Security Associations, key generation techniques, and threat mitigation e.g. denial of service and replay attacks.

6.6 Network Auditing:

Network auditing is fast becoming an indispensable tool in the maintenance of a healthy network. Network auditing software provides IT administrators with a two-pronged approach to network security. First, it provides an accurate view of the entire network and subnets, making it easier to spot any open ports, unaccounted for components or other discrepancies. Second, it allows prompt action to protect against any open vulnerability.

Conclusion

Cybercrime is a menace that should be eradicated or reduced to a very minimal level for our great nation to break even. Several prominent cybercrimes and causes have been discussed in this paper. Importance of ethical hacking in computer systems in detection, prevention and response to cyber attacks is also discussed. Identifiable measures toward strengthening Nigeria cyberspace to prevent cyber attacks and promote national security are recommended for adoption.

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APPENDIX

CASE STUDIES OF CYBERCRIMES IN NIGERIA

CASE 1 : In Nigeria prior to the gruesome murder of **Cynthia Osokogu** in July 2012, as reported by an online news magazine, people had suffered a similar fate. For example, Uzondu, an undergraduate student at a private Christian university in Ogun State, allegedly contracted the dreaded Human

Immune Virus, HIV, from a man she thought was her boyfriend.

The victim met the con man on the famous social networking platform, Face book, and before she knew it, she was whisked away to a fantasy holiday where she was lavished with expensive presents such as an iPad and the latest BlackBerry phone, among other things. During these amorous outings, the young girl became pregnant, but her partner was nowhere to be found. Unfortunately, she has no idea that the man was, no contact information, and no place of employment. Worse still, she tested positive for HIV.

CASE 2 : Mr. X (name withheld) was called and he opted-in to hear from the caller who claimed to be calling from MTN office. He was asked how long he has been using his sim… and he responded for about 15 years which was the truth. He was asked if he had received the MTN bonuses being shared to those categories of MTN users. With NO as his response, the caller further asked if he was on MTN WhatsApp group which he confirmed on the contrary. The caller then informed Mr. X that MTN will send a code to him and requested him to forward the code to him for inclusion in the WhatsApp group for the benefits which he did as directed. A minute after, he started receiving a debit alert until his account was drained of N510,000.When he reported his ordeal to his bank, internet fraud was discovered with no help anywhere.

CASE 3: Justice Muhammed Sani of the Federal High Court sitting in Ilorin convicted six persons over offences bordering on cybercrime, impersonation and other internet-related fraud. The Convicts are Adeshina Wasiu, a welder based in Offa; Hammed Akorede Hammed, who currently operates a barbing salon shop in Offa; Komolafe Shina David from Ilesha East Local Government Area of Osun and Fatimehin Kayode from Ekiti Local Government Area of Kwara State. Others are Adetoye Damilare Timilehin from Boluwaduro Local Government Area of Osun State and Adebayo Ridwan Abiola from Obokun Local Government Area of Osun State. Counsels to the Economic Financial Crimes Commission, EFCC, Innocent Mbachie, Aliyu Adebayo and Rasheedat Alao prosecuted the cases on behalf of the commission. The defendants, who were prosecuted on separate charges by the anti-graft agency before the court, pleaded guilty to their respective charges. Following their guilty pleas, the EFCC tendered from the bar iPhones, laptops, *"extra-judicial statements of the defendants and several incriminating documents"* printed out of their devices and were admitted in evidence after defence counsels raised no objection to the admissibility of the exhibits. The prosecuting counsels thereafter urged the court to convict the defendants as charged. In his judgments on the cases, Justice Sani said the prosecution had successfully established the cases against the defendants and pronounced each of them guilty of their respective charges and charged them with various jail terms. (Vanguard News Nigeria, 2022).

CASE 4 : HIGH TECHNOLOGY SCAM

There is a high technology scam going on at this time called SIM SWAP FRAUD. Hundreds of people have been affected and they suddenly found that their bank accounts were EMPTY.

How does it works*?*

The new scam called SIM SWAP starts like this:

1. Your phone network will suddenly go blank/zero (ie no signal/zero bar) and after a while you will get a call.
2. The caller will tell you that he is calling from your mobile phone provider (company) depending on your network and that there is a problem in your mobile network.
3. He will instruct you to please press1 on your phone to regain network. If do not hang up or end your phone and heed to the instruction, the network will appear suddenly in a moment your phone will go blank again (zero bar) and with this action, your hone is already hacked.

In a few seconds, he will empty your bank account and you will not receive any notification or transaction alert about it. At this time, it will appear as if you have been disconnected with no network, meanwhile your SIM has been changed (A known but undisclosed victim).

Combating Cybercrime In Nigeria: A Tool For Economic Development

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Abstract: *The advent of computer age has given rise to a lot of innovations and advancements in the 21st century. These innovations and advancements posted both positive and negative impacts on the masses as well as the global village. Cyber technology is one of the information and communication technology (ICT) based innovation and advancement brought about by the advent of computer and the internet which possess serious threats to the society and indirectly affects economic development of a nation. This paper used a descriptive survey to evaluate the positive effects of the combat of cyber-crime to Nigeria as a nation. The work employed 200 respondents, which include staff and students from the Computer Science, Cyber Security, Software Engineering and Chemistry Departments of Ritman University, Ikot Ekpene, Nigeria. The work adopted the purposive random sampling technique was applied in recruiting 50 participants in each department of the institution who have knowledge about the subject matter. In the paper, the data that were gathered from the field were studied through the use of chi-square test of independence. It was discovered that early and adequate security intelligence intervention can go a long way to guarantee security of information and enhance e-commence vis-à-vis digital economy in Nigeria which will in turn boost the economic growth of the nation.*

Keywords: Cyberspace, Cybersecurity, Cybercrime, Cyberstalking, Cyberwarfare, Unsolicited e-mail.

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James, G. G., Asuquo, J. E., Etim, E. O. and Michael, N. A. (2023). Combating Cybercrime in Nigeria: A Tool for Economic Development. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I.(Editors).*Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 478-485

Introduction

The presence of computer and computing technology has paved the way for illegal activities among youths. This is because Nigeria youths can socialize, games, carrying out financial transactions as well as manipulating camera with internet access. One of the driving forces towards the ease of doing business in developing countries is the application of Information Technology. The exploding increase to the internet access has extremely and significantly affected the method millions of citizens in developing countries executes business activities: hence the digital economy and its impending challenges. It can be assumed that in the near future, most economic activities will be done digitally leading to economic growth and sustainability. Nigeria like most developing countries has keyed into this digital economic transformation which must be safeguard through adequate cybersecurity programs.

In Nigeria particularly as well as other parts of the world, youths have hyper connectivity thereby connecting to the internet for information and social contacts. These hyperconnectivity connects the 21st generation youths in the world of social network. The newly found connectivity, therefore allows for commissioning of ancients' crimes in the new era: The Internet. These illicit activities (cybercrime) expose the victims to their victimizers, who carries out fraud, thefts or threatening communications globally. Cybercrime involves gaining illegal access to a legal entry into the computer or illegally infacing with another through the use of computer. In Nigeria, as well as the global village, the rate of cybercrime is on the high side thereby affecting e-commence negatively and by extension affects the economic growth of the Nation.

In Nigeria as well as the global village, Cybercrime statistics are escalating, both in scale and complexity (EC-Council Cybersecurity Partnership). Attacks affect everyone from essential services, such as the NHS, to multinational businesses, SMEs, and private individuals.

Each year, cybercrime causes significant financial losses and reputational damage (Fletcher, 2007). Sequel to this, as e-commerce increases via internet, it's essential to put effective cyber security measures in place to protect us and our organizations from the effects of cyber-attacks. This paper considers the combat of cybercrime as a major tool to enhance national economic development.

Insecure Cyberspace

In recent times, people witnessed golden age in social history previously symbolized by long wars and disasters but now shows a sense of unappalled development in information and communication technology and related material forms of computers and networks. Unfortunately, information systems are likely to crash, and likely to cause disputes and lawsuits without appropriate security measures in place. However, the problem in the landscaping of the social sciences is that many technological loopholes are constantly being exploited with malicious intent by these cyber criminals, while technological opportunities are, at the same time, keep generating various benefits as well. Hence, social problems are more severely holds great threats to the security, reliability and credibility of e-commerce to the information society.

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cybercrime refers to a wide range of illegal activities in which computers and information systems are used as a significant tool or as a primary target. "Other equivalent phrases, such as 'virtual crime,' 'net-crime,' 'hi-tech crime,' or 'computer crime/e-crimes,' are also frequently used to include a spectrum of illegal actions that involve information and communication technology "ICT" in nature (Wall, 2004). A crime in which a computer is the object of the crime (hacking, phishing, spamming) or is utilized as a tool to conduct an offense. In Nigeria, the rate of criminal activities via the internet is alarming. People hacks into others account as well as other social media platform to perpetrates all kinds of elicits activities, leaving their victims to depression, illnesses and death. The physical policing has minimum or no assistance to salvage these menace, as such, the progression of e-commerce is jeopardize as a lot of investors are afraid to carry out e-commerce as a results of fear of the unknown. The available government's machineries have tried all they could to content with this menace but to no avail, hence the need for effective cybercrime combat cannot be over emphasized. The researcher, is focusing on the advantages that may be derived as a nation, if these effective cyber security measures are been fully considered and it is after math positive effects

on the nation's economic growth by encouraging e-commence, e-financial transactions as well as electronics credit facilities.

Developing a good cybersecurity policies awareness and implementation in tertiary institutions is a Prerequisite to Robust Cyberspace in COVID-19 Pandemic Epoch as opined by Etim, Ogbonna & Etuk (2021), in Nigerian Tertiary Institutions, the absence of a national cyber security policy for students, staff, vendors and others to institution's network is done based on the financial, technological, skills and necessity of individual schools. In April, 2020 many realized that schools may be close for a longer period and the need for alternatives. Despite the industrial action of the Academic Staff Union of University (ASUU) many tertiary institutions both private and public decided to embark on online lectures and provision of other services to staff and students using the cyber space. Compared with western countries, the Federal Ministry of Education's school-closure directive did not produce guiding principle on how to ease learning disruptions for students and how to handle the digital means of learning which may be alternative method to physical teaching learning process in the dynamic society together with the enormous traffic on the school's network and the attendance security implications.

According to Punch Newspaper (2021) The Executive Vice Chairman, Nigerian Communications Commission (NCC), Prof. Umar Danbatta, posited that trust and confidentiality will promote a healthy digital environment, as enshrined in global best practices to guarantee the privacy and integrity of digital data. The digital economy should be built on trusted technologies and partnerships, to ensure strong cybersecurity that rides on public confidence, security, privacy and safety, to bolster responsive regulations, transparency, accountability and digital governance. However, Danbatta acknowledges the pace at which technology advanced, acceleration of innovations and enterprise in the digital space amplified vulnerability opportunities, which malicious parties were quick to exploit, thereby slowing down the gains of digital economy and that strong cybersecurity would reduce the surface of vulnerabilities in the digital economy that could be exploited. In recent times, GSM phones in Nigeria has come under attacks through SMS by cyber criminals. According to Punch Newspaper October 23, 2021, Sadiq Oyeleke posits thus; The Nigerian Communication Commission (NCC) on Friday alerted Nigerians of the existence of a new high-risk and extremely damaging, malware called Flubot. The publication listed things to know about this new virus that steals banking details from Android devices. This malware impersonates android mobile baking applications to draw fake web view on targeted applications and is circulated through Short Messages Services (SMS) and can snoop on incoming notifications, initiate calls, read or write SMSes and transmit the victim's contact list to its control center.

Categories of Cybercrime Against Economic Development in Nigeria

Traditional offenses (such as fraud, forgery, and identity theft), content-related offenses (such as online distribution of child pornography or incitement to racial hatred), and offenses specific to information systems and computers all fall under the umbrella of internet crime. Cybercrime can be divided into two general categories:

i. Crimes that directly harm computer networks and gadgets and as such destroy organizations database. Computer viruses, malicious code, and malware are a few examples.
ii. Crimes that directly harm computer networks works negatively against digital economy which is an important subsector of every

national economy needs to be urgently mitigated. According to World Bank Newsletter (2021), Africa should think big on digital development. At the current, incremental pace of economic and social advancement, too many of Africa's expanding youth population will be denied the opportunity to live up to their potential. Digital technologies offer a chance to disrupt this trajectory – unlocking new pathways for rapid economic growth, innovation, job creation and access to services which would have been unimaginable only a decade ago. Yet there is also a growing 'digital divide', and increased cyber risks, which need urgent and coordinated action to mitigate.

iii. Criminality perpetrated with PC or gadgets, the essential objective of which is autonomous of the PC or gadgets. The following are digital crime models: Misrepresentation and wholesale fraud, phishing tricks, and data fighting.

Online marketing is effectively carried out on PC and mobile devices. These devices in most cases explore public networks and free Wi-Fi available in places such as airports, stadia, restaurants, etc. Cyber criminals usually exploit these public arenas by providing free internet access to unsuspected users and use it to gain access to their devices for security and financial information mainly for malicious purposes, thereby become clog in the wheel of digital marketing. Techpoint (2020) explained that it's the year of the pandemic, and besides the ensuing economic effects, it appears companies around the globe are dealing with increased rates of cyberattacks. Unfortunately, African countries seem to be major targets. As businesses embrace emerging technology solutions like Internet-of-Things (IoT), Artificial Intelligence, and cloud computing, their exposure to cyberattacks has increased. In a recent survey, Sophos Group plc, a British security software and hardware company, revealed that 86% of Nigerian companies fell prey to cyberattacks within the past year. This is the second highest percentage recorded globally after India and much higher than in South Africa with 64%. This survey made use of data from 65 Nigerian companies that host data on public cloud-based services like Azure, Oracle, AWS, Alibaba cloud, and others

Cybercrime overlaps into terrorism at its peak, covering attacks on human life, national security establishments, key infrastructure, and other vital arteries of society.

In general, there are three forms of cybercrime attacks. These are:

a) Crime against the Individual: (i) Person like impersonation (ii) Property of an individual like clearing bank customer's account.
b) Crime against Organization like claiming organizational contract benefits (i) Government (ii) Firm, Company, and Group of Individuals.
c) Crime against Society.

Research Hypothesis

H_{01}: Cybercrime Security Intelligence Intervention do not have significant effect on national economic Developments.

H_{11}: Cybercrime Security Intelligence Intervention have significant effect on national economic Developments.

H_{02}: The achievement on combating cybercrime does not depend on the nature of crime.

H_{12}: The achievement on combating cybercrime depends on the nature of crime.

[

Research Design

The paper adopted a descriptive survey which systematically collects data and as a result, the researcher theoretically assesses the role that security intelligence could adopt as a measure to counter cybercrime and its aftermath effect on national development. The data was presented formally to staff and students of Ritman University, Ikot Ekpene, Nigeria, on the 17th, 18th

and 19th of January 2023, and were collected on the 25th of January 2023.

Research Population

The research population was drawn from staff and students of Computer Science, Cyber Security, Software Engineering and Chemistry Departments of Ritman University, Ikot Ekpene, Nigeria, which undergoes studies related to cybercrime. This study recruited 200 respondents, which include staff and students from the affected Departments. This paper adopted the purposive random sampling technique and it was used to recruit 50 participants in each Department of the institution with knowledge of the subject matter. The technique sampled 30 staffs with 2 years and above in the University System and 160 students in the 300 and 400 level of their studies. The recruitment of staffs and students was conducted physically through an introduction letter and interactions with the staff met in respective departments.

Data Collection

The data were collected at the primary and secondary sources. The primary sources were the questionnaire which have close-ended questions that were used to arrive at figures to be computed mathematically while the secondary data were the internet, published books, and journals related to the paper. The paper employs quantitative research that aimed at producing the best available data, process, and performance to aid understanding of the theme of this study. Preliminary testing was carried out with staff and students from the affected departments to assess their response to the questions and, as a result, some questions were modified before the final administration of the questionnaire. A copy of the questionnaire is attached at the Appendix section of this paper, under *Extended data* (Afolabi and Raji, 2022).

A suitable design was structured, a two-point and four-point Likert scale for each variable. A two-point scale of Yes or No and a four-point scale of strongly agree (4), agree (3), disagree (2), and strongly disagree (1). A hard copy questionnaire was sent to participants which enabled us to collect data in a less expensive, time efficient and less pressurized manner, leaving respondents to answer in their own time. The questionnaire comprised 3 sections, the first section assessed the level of cybercrime in our society. The second section viewed the nature of the cybercrime, while the third section assessed the impact of cybercrime intervention on National Development in Nigeria. The location of respondents is Ikot Ekpene, Akwa Ibom State, Nigeria and participants took about a week to complete the questionnaire.

Data Analysis

The researcher analyzed the data that were collected from the field using frequency counts, percentages, and charts for the demographic variables while the inferential aspect was analyzed using the Chi-square test of independence. However, in this work, the researcher used the Statistical Package for the Social Science to carry out the analysis.

Results

Hypothesis 1:

1. **H_{01}:** Cybercrime Security Intelligence Intervention do not have significant effect on national economic Developments.

   H_{11}: Cybercrime Security Intelligence Intervention have significant effect on national economic Developments.

Table 1 states all the questions assessing the positive effect of cybercrime security intelligence intervention on National Development in Nigeria. The table showed that 40% strongly agreed, 20% agreed, 21% disagreed and 19% strongly disagreed that there is no significant impact of cybercrime security intelligence intervention on National Development. In order to make a comprehensive deduction out of 100% of the

population, 60% of the respondents concur that the there is a significant impact of cybercrime security intelligence intervention on National Development while 40% oppose that there is no significant impact of cybercrime security intelligence intervention on National Development.

Table 1: Level of Economic Development due to Combating Cybercrime

Question	No. of Respondents
Significant Impact	40
Slight Impact	20
No Impact	40

Decision: Both the p-value (0.052) is greater than Alpha-Value (0.05) and the χ^2-Value (7.716^a) is less than the tabulated Chi-Square value at 3 degree of freedom. It is therefore concluded that Cybercrime Security Intelligence Intervention will protect e-commerce and as such enhance national economic Developments

Hypothesis 2:

1. **H_{02}:** The achievement on combating cybercrime does not depend on the nature of crime.

   H_{12}: The achievement on combating cybercrime depends on the nature of crime.

Table 2 revealed that the achievement on combating cybercrime depends on the nature of crime. The table further revealed that 45% and 25% of the staff and students agreed that the relative achievements on the combat of cybercrime by the intelligent security agents depends on the nature of crime while 20% and 15% of the staff and students' respondents disagree respectively.

Table 2: Achievements of combating of cybercrime dependency on nature of crime.

Question	No. of Respondents
Depends on Nature of Crime	45
Do not depends on Nature of Crime	20
Undecided	35

The highest percentage of 45% and 25% of staff and students respectively, agreed that the achievement on combating cybercrime is dependent on the nature of crime while 20% and 15% of the respondents disagreed.

Decision: Since both the p-value (0.043) is less than Alpha-Value (0.05) and the χ^2-Value (2.621^a) is less than the tabulated Chi-Square value at 3 degrees of freedom, it is therefore concluded that the relative achievements of the security intelligence intervention is dependent of the nature of cybercrime across both staff and students.

Discussion

This study carried out a quantitative collection of data using staff and students of Ritman University in Nigeria. The analysis of research questions reviewed two variables which are the combat of cybersecurity in Nigeria as well as the aftermath effect on National Economic Development. Findings revealed that on a scale of 1 to 4 departments of Ritman University Assurance experience a 5-scale rating. There is internal and external vulnerability which is a threat to the National Economic Development of Nigeria. It was realized that people experience fewer cyber-attacks in financial institutions, meaning customers are confident with their information on the company's database, but more attacks on the mobile platforms. However, due to the rise in cybercrime activities in Nigeria and against corporate bodies, financial institutions in Nigeria need more security operational posture in order to be proactive and guard against cybercrime attacks. There are several types or nature of cybercrime attacks across the globe. Thus, findings reveal that the top five cybercrime attacks affecting financial institutions in Nigeria are phishing scams, website spoofing, piracy, ransom-ware, and hacking. Particularly, a phishing scam with 90% is prevalent and it is the most used measure to commit cybercrime, while website spoofing,

piracy, and hacking are within 50%-60%. If with the government take advantage of the advent of IT infrastructure, tools and measures that there is hope of reducing cyber-attacks on corporate bodies in Nigeria and enhancing the national economic development; then more proactive innovation or techniques should be tested and applied. Thus, findings reveal that security threat data or information that has been collected and analyzed should be disseminated to appropriate security bodies which would bring awareness of the type of prevalent attack in organization as well as individuals.

Recommended Cybercrime Protection Measures

The following are the most common cybercrime protection methods:

1. Firewall

This is the ICT technology which helps victims to resist network traffic therefore protecting against cyber-attack by blocking traffic based on a well-define set of rules.

2. Secure Configuration

Brand new, out-of-the-box computers and devices are not always secure in their default configurations. They often include weak points such as admin accounts with insecure passwords or come without multi-factor authentication enablement. Default installations provide cyber criminals with easy opportunities to gain access to an organization's sensitive information. By applying some technical controls when setting up your computers and devices, you can minimize vulnerabilities and increase your protection against cyber-attacks.

3. User Access Control

This technology helps the victim account to be protected using multiple factor authentication rule as such it ensures that only authorized persons can have access to perform certain rules. This technique when fully implemented, reduces the risk of information been stolen or damaged by these cyber criminals.

4. Malware Protection

The act of downloading software and files from the internet can expose a device to a malware infection. Malware, such as viruses, worms, and spyware, are softwares that have been written and distributed with malicious intent. Potential sources of malware include email attachments, app downloads and the installation of unauthorized software. If your systems get infected with malware, you will likely suffer from data loss, malfunctioning systems, and continues infections.

5. Security Update

This ensures the use of only licensed and supported software to enable automatic updates which in turn protects people businesses from potential cyber attack

Conclusion

The level of cybercrime in financial institutions in Nigeria was found to be too high by the respondents. There is also a high level of perception of the nature of cybercrime. These becomes a threat to financial institutions as well as cooperate organizations to carry out e-commence which inferably affect the economic growth of the nation. The paper indicate that early and adequate security intelligence intervention can go a long way to guarantee security of information and enhance e-commence in Nigeria which will in turn boost the economic growth of the nation.

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cybercrime refers to a wide range of illegal activities in which computers and information systems are used as a significant tool or as a primary target. "Other equivalent phrases, such as 'virtual crime,' 'net-crime,' 'hi-tech crime,' or 'computer crime/e-crimes,' are also frequently used to include a spectrum of illegal actions that involve information and communication technology "ICT" in nature (Wall, 2004). A crime in which a computer is the object of the crime (hacking, phishing, spamming) or is utilized as a tool to conduct an offense. In Nigeria, the rate of criminal activities via the internet is alarming. People hacks into others account as well as other social media platform to perpetrates all kinds of elicits activities, leaving their victims to depression, illnesses and death. The physical policing has minimum or no assistance to salvage these menace, as such, the progression of e-commerce is jeopardize as a lot of investors are afraid to carry out e-commerce as a results of fear of the unknown. The available government's machineries have tried all they could to content with this menace but to no avail, hence the need for effective cybercrime combat cannot be over emphasized. The researcher, is focusing on the advantages that may be derived as a nation, if these effective cyber security measures are been fully considered and it is after math positive effects

on the nation's economic growth by encouraging e-commence, e-financial transactions as well as electronics credit facilities.

Developing a good cybersecurity policies awareness and implementation in tertiary institutions is a Prerequisite to Robust Cyberspace in COVID-19 Pandemic Epoch as opined by Etim, Ogbonna & Etuk (2021), in Nigerian Tertiary Institutions, the absence of a national cyber security policy for students, staff, vendors and others to institution's network is done based on the financial, technological, skills and necessity of individual schools. In April, 2020 many realized that schools may be close for a longer period and the need for alternatives. Despite the industrial action of the Academic Staff Union of University (ASUU) many tertiary institutions both private and public decided to embark on online lectures and provision of other services to staff and students using the cyber space. Compared with western countries, the Federal Ministry of Education's school-closure directive did not produce guiding principle on how to ease learning disruptions for students and how to handle the digital means of learning which may be alternative method to physical teaching learning process in the dynamic society together with the enormous traffic on the school's network and the attendance security implications.

According to Punch Newspaper (2021) The Executive Vice Chairman, Nigerian Communications Commission (NCC), Prof. Umar Danbatta, posited that trust and confidentiality will promote a healthy digital environment, as enshrined in global best practices to guarantee the privacy and integrity of digital data. The digital economy should be built on trusted technologies and partnerships, to ensure strong cybersecurity that rides on public confidence, security, privacy and safety, to bolster responsive regulations, transparency, accountability and digital governance. However, Danbatta acknowledges the pace at which technology advanced, acceleration of innovations and enterprise in the digital space amplified vulnerability opportunities, which malicious parties were quick to exploit, thereby slowing down the gains of digital economy and that strong cybersecurity would reduce the surface of vulnerabilities in the digital economy that could be exploited. In recent times, GSM phones in Nigeria has come under attacks through SMS by cyber criminals. According to Punch Newspaper October 23, 2021, Sadiq Oyeleke posits thus; The Nigerian Communication Commission (NCC) on Friday alerted Nigerians of the existence of a new high-risk and extremely damaging, malware called Flubot. The publication listed things to know about this new virus that steals banking details from Android devices. This malware impersonates android mobile baking applications to draw fake web view on targeted applications and is circulated through Short Messages Services (SMS) and can snoop on incoming notifications, initiate calls, read or write SMSes and transmit the victim's contact list to its control center.

Categories of Cybercrime Against Economic Development in Nigeria

Traditional offenses (such as fraud, forgery, and identity theft), content-related offenses (such as online distribution of child pornography or incitement to racial hatred), and offenses specific to information systems and computers all fall under the umbrella of internet crime. Cybercrime can be divided into two general categories:

i. Crimes that directly harm computer networks and gadgets and as such destroy organizations database. Computer viruses, malicious code, and malware are a few examples.
ii. Crimes that directly harm computer networks works negatively against digital economy which is an important subsector of every

national economy needs to be urgently mitigated. According to World Bank Newsletter (2021), Africa should think big on digital development. At the current, incremental pace of economic and social advancement, too many of Africa's expanding youth population will be denied the opportunity to live up to their potential. Digital technologies offer a chance to disrupt this trajectory – unlocking new pathways for rapid economic growth, innovation, job creation and access to services which would have been unimaginable only a decade ago. Yet there is also a growing 'digital divide', and increased cyber risks, which need urgent and coordinated action to mitigate.

iii. Criminality perpetrated with PC or gadgets, the essential objective of which is autonomous of the PC or gadgets. The following are digital crime models: Misrepresentation and wholesale fraud, phishing tricks, and data fighting.

Online marketing is effectively carried out on PC and mobile devices. These devices in most cases explore public networks and free Wi-Fi available in places such as airports, stadia, restaurants, etc. Cyber criminals usually exploit these public arenas by providing free internet access to unsuspected users and use it to gain access to their devices for security and financial information mainly for malicious purposes, thereby become clog in the wheel of digital marketing. Techpoint (2020) explained that it's the year of the pandemic, and besides the ensuing economic effects, it appears companies around the globe are dealing with increased rates of cyberattacks. Unfortunately, African countries seem to be major targets. As businesses embrace emerging technology solutions like Internet-of-Things (IoT), Artificial Intelligence, and cloud computing, their exposure to cyberattacks has increased. In a recent survey, Sophos Group plc, a British security software and hardware company, revealed that 86% of Nigerian companies fell prey to cyberattacks within the past year. This is the second highest percentage recorded globally after India and much higher than in South Africa with 64%. This survey made use of data from 65 Nigerian companies that host data on public cloud-based services like Azure, Oracle, AWS, Alibaba cloud, and others

Cybercrime overlaps into terrorism at its peak, covering attacks on human life, national security establishments, key infrastructure, and other vital arteries of society.

In general, there are three forms of cybercrime attacks. These are:

a) Crime against the Individual: (i) Person like impersonation (ii) Property of an individual like clearing bank customer's account.
b) Crime against Organization like claiming organizational contract benefits (i) Government (ii) Firm, Company, and Group of Individuals.
c) Crime against Society.

Research Hypothesis

H_{01}: Cybercrime Security Intelligence Intervention do not have significant effect on national economic Developments.

H_{11}: Cybercrime Security Intelligence Intervention have significant effect on national economic Developments.

H_{02}: The achievement on combating cybercrime does not depend on the nature of crime.

H_{12}: The achievement on combating cybercrime depends on the nature of crime.

[

Research Design

The paper adopted a descriptive survey which systematically collects data and as a result, the researcher theoretically assesses the role that security intelligence could adopt as a measure to counter cybercrime and its aftermath effect on national development. The data was presented formally to staff and students of Ritman University, Ikot Ekpene, Nigeria, on the 17th, 18th

and 19th of January 2023, and were collected on the 25th of January 2023.

Research Population

The research population was drawn from staff and students of Computer Science, Cyber Security, Software Engineering and Chemistry Departments of Ritman University, Ikot Ekpene, Nigeria, which undergoes studies related to cybercrime. This study recruited 200 respondents, which include staff and students from the affected Departments. This paper adopted the purposive random sampling technique and it was used to recruit 50 participants in each Department of the institution with knowledge of the subject matter. The technique sampled 30 staffs with 2 years and above in the University System and 160 students in the 300 and 400 level of their studies. The recruitment of staffs and students was conducted physically through an introduction letter and interactions with the staff met in respective departments.

Data Collection

The data were collected at the primary and secondary sources. The primary sources were the questionnaire which have close-ended questions that were used to arrive at figures to be computed mathematically while the secondary data were the internet, published books, and journals related to the paper. The paper employs quantitative research that aimed at producing the best available data, process, and performance to aid understanding of the theme of this study. Preliminary testing was carried out with staff and students from the affected departments to assess their response to the questions and, as a result, some questions were modified before the final administration of the questionnaire. A copy of the questionnaire is attached at the Appendix section of this paper, under *Extended data* (Afolabi and Raji, 2022).

A suitable design was structured, a two-point and four-point Likert scale for each variable. A two-point scale of Yes or No and a four-point scale of strongly agree (4), agree (3), disagree (2), and strongly disagree (1). A hard copy questionnaire was sent to participants which enabled us to collect data in a less expensive, time efficient and less pressurized manner, leaving respondents to answer in their own time. The questionnaire comprised 3 sections, the first section assessed the level of cybercrime in our society. The second section viewed the nature of the cybercrime, while the third section assessed the impact of cybercrime intervention on National Development in Nigeria. The location of respondents is Ikot Ekpene, Akwa Ibom State, Nigeria and participants took about a week to complete the questionnaire.

Data Analysis

The researcher analyzed the data that were collected from the field using frequency counts, percentages, and charts for the demographic variables while the inferential aspect was analyzed using the Chi-square test of independence. However, in this work, the researcher used the Statistical Package for the Social Science to carry out the analysis.

Results

Hypothesis 1:

1. **H_{01}:** Cybercrime Security Intelligence Intervention do not have significant effect on national economic Developments.

   H_{11}: Cybercrime Security Intelligence Intervention have significant effect on national economic Developments.

Table 1 states all the questions assessing the positive effect of cybercrime security intelligence intervention on National Development in Nigeria. The table showed that 40% strongly agreed, 20% agreed, 21% disagreed and 19% strongly disagreed that there is no significant impact of cybercrime security intelligence intervention on National Development. In order to make a comprehensive deduction out of 100% of the

population, 60% of the respondents concur that the there is a significant impact of cybercrime security intelligence intervention on National Development while 40% oppose that there is no significant impact of cybercrime security intelligence intervention on National Development.

Table 1: Level of Economic Development due to Combating Cybercrime

Question	No. of Respondents
Significant Impact	40
Slight Impact	20
No Impact	40

Decision: Both the p-value (0.052) is greater than Alpha-Value (0.05) and the χ^2-Value (7.716^a) is less than the tabulated Chi-Square value at 3 degree of freedom. It is therefore concluded that Cybercrime Security Intelligence Intervention will protect e-commerce and as such enhance national economic Developments

Hypothesis 2:

1. **H_{02}:** The achievement on combating cybercrime does not depend on the nature of crime.

   H_{12}: The achievement on combating cybercrime depends on the nature of crime.

Table 2 revealed that the achievement on combating cybercrime depends on the nature of crime. The table further revealed that 45% and 25% of the staff and students agreed that the relative achievements on the combat of cybercrime by the intelligent security agents depends on the nature of crime while 20% and 15% of the staff and students' respondents disagree respectively.

Table 2: Achievements of combating of cybercrime dependency on nature of crime.

Question	No. of Respondents
Depends on Nature of Crime	45
Do not depends on Nature of Crime	20
Undecided	35

The highest percentage of 45% and 25% of staff and students respectively, agreed that the achievement on combating cybercrime is dependent on the nature of crime while 20% and 15% of the respondents disagreed.

Decision: Since both the p-value (0.043) is less than Alpha-Value (0.05) and the χ^2-Value (2.621^a) is less than the tabulated Chi-Square value at 3 degrees of freedom, it is therefore concluded that the relative achievements of the security intelligence intervention is dependent of the nature of cybercrime across both staff and students.

Discussion

This study carried out a quantitative collection of data using staff and students of Ritman University in Nigeria. The analysis of research questions reviewed two variables which are the combat of cybersecurity in Nigeria as well as the aftermath effect on National Economic Development. Findings revealed that on a scale of 1 to 4 departments of Ritman University Assurance experience a 5-scale rating. There is internal and external vulnerability which is a threat to the National Economic Development of Nigeria. It was realized that people experience fewer cyber-attacks in financial institutions, meaning customers are confident with their information on the company's database, but more attacks on the mobile platforms. However, due to the rise in cybercrime activities in Nigeria and against corporate bodies, financial institutions in Nigeria need more security operational posture in order to be proactive and guard against cybercrime attacks. There are several types or nature of cybercrime attacks across the globe. Thus, findings reveal that the top five cybercrime attacks affecting financial institutions in Nigeria are phishing scams, website spoofing, piracy, ransom-ware, and hacking. Particularly, a phishing scam with 90% is prevalent and it is the most used measure to commit cybercrime, while website spoofing,

piracy, and hacking are within 50%-60%. If with the government take advantage of the advent of IT infrastructure, tools and measures that there is hope of reducing cyber-attacks on corporate bodies in Nigeria and enhancing the national economic development; then more proactive innovation or techniques should be tested and applied. Thus, findings reveal that security threat data or information that has been collected and analyzed should be disseminated to appropriate security bodies which would bring awareness of the type of prevalent attack in organization as well as individuals.

Recommended Cybercrime Protection Measures

The following are the most common cybercrime protection methods:

1. Firewall

This is the ICT technology which helps victims to resist network traffic therefore protecting against cyber-attack by blocking traffic based on a well-define set of rules.

2. Secure Configuration

Brand new, out-of-the-box computers and devices are not always secure in their default configurations. They often include weak points such as admin accounts with insecure passwords or come without multi-factor authentication enablement. Default installations provide cyber criminals with easy opportunities to gain access to an organization's sensitive information. By applying some technical controls when setting up your computers and devices, you can minimize vulnerabilities and increase your protection against cyber-attacks.

3. User Access Control

This technology helps the victim account to be protected using multiple factor authentication rule as such it ensures that only authorized persons can have access to perform certain rules. This technique when fully implemented, reduces the risk of information been stolen or damaged by these cyber criminals.

4. Malware Protection

The act of downloading software and files from the internet can expose a device to a malware infection. Malware, such as viruses, worms, and spyware, are softwares that have been written and distributed with malicious intent. Potential sources of malware include email attachments, app downloads and the installation of unauthorized software. If your systems get infected with malware, you will likely suffer from data loss, malfunctioning systems, and continues infections.

5. Security Update

This ensures the use of only licensed and supported software to enable automatic updates which in turn protects people businesses from potential cyber attack

Conclusion

The level of cybercrime in financial institutions in Nigeria was found to be too high by the respondents. There is also a high level of perception of the nature of cybercrime. These becomes a threat to financial institutions as well as cooperate organizations to carry out e-commence which inferably affect the economic growth of the nation. The paper indicate that early and adequate security intelligence intervention can go a long way to guarantee security of information and enhance e-commence in Nigeria which will in turn boost the economic growth of the nation.

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Internet Of Things (Iot) For Smart Home Security In Nigeria

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Abstract: *Smart home security is the use of ICT in managing security of homes even in our absence. The smart home is a residential-base platform that uses Internet of Things (IoT), computer technology, control technology, image display technology and communication technology to connect various facilities through the network to meet the automation requirements of the entire system and provide more convenient control and management. This paper analysis the important of smart home security, give the smart home composition and the application of key equipment and smart home key technologies used in smart home security and how the equipment's communicate.*

Keywords: Smart home, Inter of Things (IoT), Communication technology

CITATION:

Billy, D. A. and Billy, P. A. (2023). Internet of Things (IoT) for Smart Home Security in Nigeria. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 470-477

Introduction

Smart home refers to the use of IC'T in home management, starting from controlling appliances to automation of home features (windows, lighting, etc.). A key element of the smart home is the usage of intelligent power scheduling algorithms, which will provide residents with the ability to make optimal, a prior choices about how to spent electricity in order to decrease energy consumption. Another term commonly used is smart house or home automation. The combination of information technologies and advanced communication and sensing systems, creates a variety of new potential applications (Kim, Marc and Ayman, 2019). Smart devices or at first instant, write all the authors objects, capable of communication and computation, ranging from simple sensor nodes to home appliances and sophisticated appliances.

The heterogeneous network composing of such objects comes under the umbrella of a concept with a fast-growing popularity, referred to as Internet of Things (IoT). IoT represents a worldwide network of uniquely addressable interconnected objects. According to (Gubbi, *Andrea, Angelo Lorenzo* and *Michele*, 2018), IoT is an "inter connection of sensing and actuating devices providing the ability to share information across platforms through a unified framework, developing a common operating picture for enabling innovative applications. This is achieved by seamless ubiquitous sensing, data analytics. Therefore, the Internet of Things aims to improve one's comfort and efficiency, by enabling cooperation among smart objects. The standard IoT usually consists of many Wireless Sensor Networks (WSN) and Radio-frequency identification **(**RFID) devices. Wireless sensor Network is a paradigm that was hugely explored by the analysis community in the' last 20 years (Oppermann, Micheal, Stefan and Torsten., 2014). A WSN consists of smart' sensing devices that can communicate through direct radio

communication. RFID devices are not sophisticated. They primarily consist of two parts: A microcircuit with some machine capabilities and antenna for communication.

The review on 'the Internet of things (Iot) for smart home security in Nigeria is vital because of the followings'

1. One of the most important issues of the emergent requirements facing the smart home development is related to cyber security', both for the wireless and the wired parts of the home. This work is of immense importance to everybody because it provides security solution to our home even when we are not around our houses but we can monitor our homes from any location that we are.
2. The first and most obvious advantage of Smart Homes is comfort and convenience. Smart homes inculcate high technology sensors to detect activities of a specific home device or appliance initiated at the absence of the home keeper.
3. Data transmitted by the sensor devices in the home can be used for security purposes. At the absence of the home keeper, the keeper could have respite when away from the home as he /she is sure to be notified of movements and intrusion in the home.
4. IT automation will be the key to bridging the gap between human limitations and technology's capabilities. With automation, data can be instantly collected and seamlessly passed between devices as it's simultaneously analyzed.

Home Automation System

In this section, the discussion is focused on different Home Automation System with their technology and features, benefit and limitations they have according to The International Journals of Computer Applications (0975 - 8887) and National Seminar on Recent Trends in Data Mining 2016 (RTDM 2016). The Diagrame below shows Basic Architecture of Remote Home Automation.

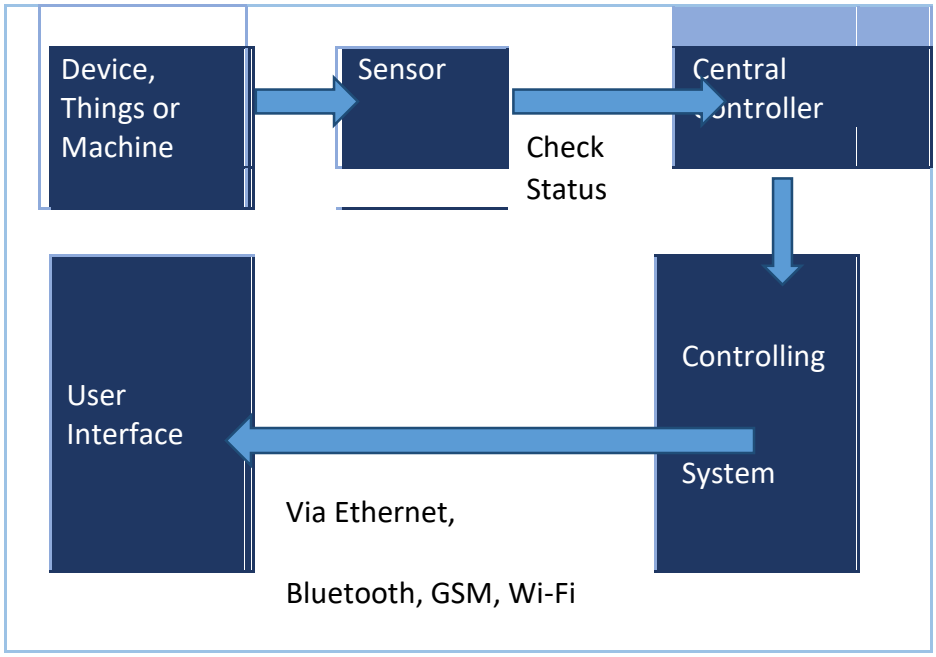

Fig. 1: Basic Block Diagram of Home Automation

This diagram of home automation framework platform developed by integrating various hardware and software resources and various tools and services based on qualified set of assumptions. It enables efficient design and development of automated test scripts and reliable analysis of issues for the system. The architecture of home automation is based on the appliances fault detection unit, safety unit and monitoring unit. This smart object in inter of Things (IoT) is able to detect their state and share it with other objects across the internet, thus collaboratively making intelligent decisions on their own**.**

Wi-Fi-based using Arduino Microcontroller, Web service and Android App Based using Raspberry pi, Cloud ,Based Using Hadoop System, Email Based using Raspberry pi, Cloud Based using Zig Bee Microcontroller, Smart Task Scheduling Based using Arduino and Android, Wireless Sensors Based with mobile Technology, Android based using Arduino, Konnex-Bus based using Raspberry pi, Dual tone multi frequency (DTMF) used in telephone lines, GSM Based using PIC Microcontroller, GSM Based Using Arduino, Bluetooth Based using Arduino are all home automation systems that aids in privacy and home security.

Wi-Fi-based using Arduino Microcontroller

The Home automation system that uses Wi-Fi technology. System consists of three main components; web server, which presents system core that controls, and monitors users' home and hardware interface module (Arduino PCB (ready-made), Wi-Fi shield PCB, 3 input alarms PCB, and 3 output actuators PCB.), which provides appropriate interface to sensors and actuator of home automation system. The System is better from the scalability and flexibility point of view than the commercially available home automation systems. The User may use the same technology to login to the server web-based application. If server is connected to the internet, so remote users can access server web-based application through the internet using compatible web browser.

Web service and Android App Based using Raspberry pi

The application was developed based on the android system. An interface card has been developed to assure communication between the remote user, server, raspberry pi card and the home Appliances. The application can be installed on an android Smartphone, a web server, and a raspberry pi card to control the shutter of windows. Android application on a smartphone issue command to raspberry pi cardand interface card would update signals between the actuator sensors and the raspberry pi card.

Cloud Based Using Hadoop System

Cloud-based home appliance monitoring and controlling System. Design and implement a home gateway to collect metadata from home appliances and send to the cloud-based data server to store on HDFS (Hadoop Distributed File System), process them using MapReduce and use to provide a monitoring function to Remote user.

Email Based using Raspberry pi

Home automation has been implemented with Raspberry Pi through reading the subject of E-mail and the algorithm. Raspberry Pi proves to be a powerful, economic and efficient platform for implementing the smart home automation. Raspberry pi based home automation is better than other home automation methods in several ways. For example, in home automation through DTMF (dual tone multi-frequency), the call tariffis a huge disadvantage, which is not the case in their proposed method. Also, in Web server-based home automation, the design of web

server and the memory space required is ejected by this method, because it simply uses the already existing web server service provided by G-mail. LEDs were used to indicate the switching action. System is interactive, efficient and flexible.

Cloud Based using Zig Bee Microcontroller

Shih-Pang Tseng et al. proposed Smart House Monitor & Manager (SHMM), based on the ZigBee, all sensors and actuators are connected by a ZigBee wireless network. They designed a simple smart socket, which can remote control via ZigBee. PC host is used as a data collector and the motion sensing, all sensing data are transferred to the VM in the cloud. The user can use the PC or Android phone to monitor or control through the Internet to power-saving of the house.

Smart Task Scheduling Based using Arduino and Android

Arduino microcontroller receives user commands to execute through an Ethernet shield. House network uses both wireless ZigBee and wired X10 technologies. This system followed smart task scheduling with a heuristic for the Resource-constrained-scheduling problem (RCPSP). The mobile device can be either wired to the central controller through USB cable or communicates with it wirelessly, within the scope of the home. Arduino contains the web server application that communicates through the HTTP protocol with Web-based Android application. The system is highly flexible and scalable and expandable.

Wireless Sensors Based with mobile Technology

This is a home network which monitors the appliances and sensors and transmits data to the cloud-based data server which manages the information and provides services for users by transmitting data and receiving user commands from mobile application. The system has good modularity and configurability characteristics with very low power consumption in cost efficient way.

Android based using Arduino

The sensors and actuators/relays are directly interfaced to the main controller. The design offers the control of energy management systems such as lightings, heating, air conditioning, security, fire detection and intrusion detection with siren and email notifications.

Konnex-Bus based using Raspberry pi

Embedded system Raspberry Pi to serve as a communication gateway between mobile devices and Konnex-Bus (KNX) home automation systems. Store the information of all actors and sensors within a Smart Home, instead of using separate profiles. Ensures energy-consumption could be reduced, compared to a standard desktop computer.

Dual tone multi frequency (DTMF) used in telephone lines

There are three components in the system DTMF receiver and ring detector, IO interface unit, PC. The PC detects the ringing of the line and then authenticates the user and use the keypad tones to control the devices as required. An example of stepper motor control is taken up. This system has the advantage of being secure and allowing international standardization. This is because the DTMF tones are the same all over the world. But it suffers from the drawback that the number of appliances is limited by the number of keys in the keypad.

GSM Based using PIC Microcontroller

PIC16F887 microcontroller for home appliances controls with GSM for control of the appliances. It has high availability, coverage and security but the cost of SMS. AT commands can be sent through the GSM network to controls the home devices. The system does not does not have anystate information related to the devices and expects the user to keep track of it.

GSM Based Using Arduino

Arduino board is the controller used to control the appliances by using GSM technology. It uses certain peripheral drivers and relays to achieve this interfacing. The application on smartphone generates SMS messages based on the user commands and sends it to the GSM mode attached to the Arduino and control the home appliances. The system has drawbacks of cost and reliability of SMS. An interface cannot be customized based on devices.

Bluetooth Based using Arduino

Arduino board with Bluetooth board were developed for home automation. Python program is used on the cell phone to provide the user interface. The Bluetooth board has I/O ports and relays are used for interfacing with the devices which are to be controlled and monitor. The Bluetooth is password protected to ensure that the system is secure from intruders. The Bluetooth has a range of 30 (Adorama, 2021). The different systems, their communication interface, the controller, user interface, applications and the benefits of the home automation to privacy and home security.

Table 1: Systems Table and Its Characteristics

System	Communication Interface	Controller	User Interface	Applications	Benefits
Wi-Fi based using Arduino Microcontroller	Wireless LAN and Wi-Fi shield	Hardware interface module	web based Application.	Temperature and humidity, Motion detection, Fire detection, Door status, Light level, Video monitoring, Controlling appliances	Low cost, Secure, Ubiquitously accessible, Auto-configurable, Remotely controlled
Web service and android app Based using Raspberry pi	Web server and interface card	Raspberry pi	Android application	Controlling shutter of window	Autonomous, and Quite scalable
Cloud Based Using Hadoop System	Cloud based data server uses Hadoop Technology	Home gateway and Router	Smart device	Monitoring and Controlling Home Appliances	Effectively manage Semi structured And unstructured data, Reduce computational burden of smart devices
Email Based using Raspberry pi	Internet Modem	Raspberry pi	E-mail	Switching LED	Smart, Economic and Efficient
Cloud Based Using Zig	Zig bee wireless	Smart Socket	PC or	entrance control management,	Convenience,

Bee Microcontroller	Network		Android Phone	monitoring the power consumption, temperature and humidity	safety, and Power-saving
Smart Task Scheduling Based using Arduino and Android	Wired X10 and Wireless Zig bee	Arduino	Android Application	Energy Management and task scheduling with power and cost	Energy-efficient and Highly scalable
Wireless Sensors Based-with mobile Technology	cloud-based data server	PCB circuits	Mobile Application	monitor the home conditions and power consumption of appliance	Low power consumption And system cost efficiency.
Android based using Arduino	Micro Web Server	Arduino Mega 2560 and the Arduino Ethernet shield	Android App	Light switches, Temperature ,Humidity sensors, Intrusion detection,, Smoke/Gas sensor	Feasibility and Effectiveness
Konnex-Bus based using raspberry pi	SIP Provider	Raspberry pi and Konnex Bus	Mobile App	Lights Control, Temperature Monitoring	Performance improved ,energy-consumption could be Reduced.
By Using DTMF	DTMF Receiver	Logical Controller with I/O interface	Computer	Authentication of user by ringing line	Secure and allow International Standard
GSM Based Using PIC Microcontroller	SMS	PIC16F887 microcontroller	Mobile phone	Control appliances	High availability, coverage and
GSM Based Using Arduino	SMS	Arduino	Smartphone App	Control appliances	Simplicity
Bluetooth Based using Arduino	Bluetooth	Arduino	Python supported mobile	controlling	Secured and Low cost

Challenges of IoT in Smart Home

The work of Greichen (2016) discussed some of the early challenges faced by Smart home systems. These include high manufacturing costs, high development costs, high installation costs, additional service and support costs, lack of home automation standards, consumer unfamiliarity withtechnology, and complex user interfaces. With the advancement of time, rapid development in technology and processing power which leads to a considerable reduction in device cost and size. All of these factors have contributed to the popularity of electronic devices today, so people are no longer confused

or unsure about the use of the computer, mobiles, or tablets. Moreover, a lot of home automation protocols, communication and interface standards (Ahmed and Karim 2016).

Methodology

The system architecture proposed and implemented includes the deployment of the Wi-Fi based home automation system using cell phones and other technology gadgets. It is intended that the final output would be run on a mobile device to enable real-time communication with the home (smart home), this led to the consideration of a mobile tool (Android) compatible framework. Framework deployed in this study includes Python, Net bean and Node.js web development framework with a procedural query style.

The android system for mobile computing was used for mobile interfacing. The system is expected to run a mobile device and communicate with the home via the internet, this ensured that a network card ready mobile device is used with strong network communication transceiver for to and fro communication with the internet both for the mobile device and the home appliances. It offers a quick connection when users smart phone and sensor gateway are in the same private network.

Results

After the execution and implementation of the program, many results would be achieved among other things a complete functional and secured automated home with a state-of-the-art security technology. The security of the home is to a large extent guaranteed as the home owner would maintain constant real time knowledge of the security situation of the home. Most times disaster in homes begins from a very small uncontrolled event, signals are sent to individuals on the present state of the equipment and electrical devices in the house. It helps the home owners know if he/ she need to get home before such situation goes out of hand. In this type of system, there is little or no need for human or animal security presence as signal is sent to home managers via sensitive home gadgets at real time.

The system uses mobiles or computers to control basic home appliances and function automatically through internet from anywhere around the world globally, an automated home is sometimes called a smart home. It is meant to save the electric power and human energy. The system is a distributed home automation system, consists of server i.e. Wi-Fi module, sensors. Server controls and monitors the various sensors, and can be easily configured to handle more hardware interface module (sensors). Automation System can be accessed from the web browser of any local PC using server IP, or remotely from any PC or mobile handheld device connected to the internet with appropriate web browser through server real IP (internet IP). Wi-Fi technology is selected to be the network infrastructure that connects server and the sensors (Hayet 2014). Wi-Fi is chosen to improve system security (by using secure Wi-Fi connection), and to increase system mobility and scalability.'

Conclusion

Internet of Things (IOT) have enormous benefits to our home security, and to a greater percentage assures the owner of the home that his or her home can be secured or can maintain real time knowledge of the security situation of his or her home from any location (Jain and zolanvari 2017). From the findings it could be concluded that our automated homes can be guaranteed maximum security as majority of the home disasters that could occur can averted or controlled. Furthermore, it shows that with automated homes, there is little or no need for human or animal security presences in our automated homes (Zolanvari and Jain, 2015).

Recommendations

1. It is recommended that data flows between devices, gateway, homes and wide area networks should be protected from being intercepted.
2. Network servers need to have standard online server level of security such as secure user sign up, sign in and access control as well as protection from denial-of-of service attacks.
3. Government should encourage integration oh information technology into the society.
4. Government should provide free or subsidize wireless internet (WIFI) to the citizens' to help in home automation

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Risk Management And Corporate Governance In Nigeria

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Abstract: *This paper made a review on Risk Management and Corporate Governance in Nigeria. Risk management of an organization consist of defining the risk, identifying and evaluating the impact and probability of materialization. Subsequently, Risk management and corporate Governance establishes appropriateness among the new-comers in the context of the concept of corporate governance, which brings a holistic perspective as an integration factor to the organization as a whole. Risk management is a corporate governance issue. It is the responsibility of the board of directors to safeguard the assets of the company and to protect the investment of the shareholders from loss of value. They board is expected to keep strategic risk within limits that shareholders would expect, and also avoid or control operational risk challenges associated with risk management such as: Lack of a common definition of critical risk terms, Lack of cultural or context understanding of the organizations function, or process being risk assessed, lack of executive management support for the risk assessment, failure to take known risk into account. failure in communicating risk to top management, failure in monitoring and managing risk and failure to use the appropriate risk metrics. It was concluded and recommended that Often times risk assessment is structured so that business managers only capture the known risk leaving the unknown which affects the strategic goals of an organization. However, in many cases its unknown risk that contributes and facilitates risk assessments there is need to learn the various risk faced by an organization and how to assess them in order to handle the risk effectively. The board in discharging its role must be vested with risk management procedures and ensure that the Enterprise Risk Management model (ERM) is strictly adopted by the board of any organization.*

Keywords: Risk management, Corporate Governance, risk assessment, executive management

CITATION:

Etuk, M. U. and Eyo, U. E. (2023). Risk Management and Corporate Governance in Nigeria. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 462-469

Introduction:

Financial scandals around the world and the collapse of major corporate institutions have brought to the fore, the need for the practice of good corporate governance. An important theme of corporate governance is the nature and extent of accountability of particular individuals in the organization and mechanisms that try to eliminate the principal agent problem. Corporate governance provides the structure through which the objectives of the company are set and the means of attaining those objective and monitoring performance are determined.

Regardless of whether the global financial crisis resulted from excessive risk taking (kashyap, Rajan and Stein 2008 cited by Hutchinson 2013). Risk management of an organization consist of defining the risk, identifying and evaluating the impact and probability of materialization. Subsequently, establishing appropriate among the new-comers in the context of the concept of corporate governance, which brings a holistic

perspective as an integration factor of the part of a whole, which is the organization. Under corporate governance, any entity, risk management is necessary because both in the company and in the field in which it acts, there are uncertainties of the nature of threats in the increase occurrence. This concern has been largely attributed to bank failures. Considering the Nigerian banking sector, it was gathered that, management of poor credit-risk, internal as well as external supervision needs impede stability as well as the profitability of banks (Obi, 2012). Mehmood *et al.,* 2019 stated that the stability and underlying performance of listed deposit money bank within the economy is vital and paramount to macroeconomic development of a nation. Not only that, corporate governance failure linked to banks poor performance and reporting failure are very worrisome as the impact of high-profile cases cumulatively had resulted in a steady- loss of investments, credibility and confidence in banks ability in payback of depositors' fund and their credit risk. Also Nwege (2012) noted that, in the part Nigeria banks were always carrying toxic assets in the form of enormous amount which keeps rising progressively from one period to another and has never been resolved through good credit risks management. Cited the case of 33 bank liquidated between the period of 1994-2000. This was as a result of non-performing loans (NPL). This management of risk in an indispensable aspect of the success of an organization, which should be manage d properly. However, to resolve these issues the central bank has a supervision role in maintaining a balance between financial performance and effective corporate governance while considering inherent risk factors. These risks can be managed effectively where quality control is in place (Olamide *et al*., 2015).

Concept of Corporate Risk and Risk Management

achievement of objectives, or the nature of opportunities. Any manager must consider the way these risks can be effectively managed.
Chiejina (2016) opined that financial crisis in banking sector has been worrisome for either bank regulators or owners as a result of an

Risks are usually associated with the possibility that things might go wrong or that errand might turn out worse than expected or that something bad might happen. Risk exist whenever future events cannot be predicted with certainty. Organization are usually faced with pure and speculative risk. Pure risks are those often controlled either by means of internal control or by insurance. They may be called internal control risk or operational risk. Speculative risks on the other hand, are those risks which cannot be avoided because risk must be taken in order to make profit. A general rule states that higher risk is justified by expectation of higher profit but an organization needs to decide what level of risk is acceptable speculative risk is otherwise known as business risk or strategic risk.

Risk management is the process of identifying, assessing reviewing and controlling threats to an organization's capital and earnings as indicated in diagram 1. These risk stern from varieties which includes financial uncertainties legal liabilities, technology issues, strategic management errors, accidents and natural disasters. It is also the process of managing both downside risks and business risk. It could be defined as the culture, structures, and process that are focused on a achieving possible opportunities yet at the same true control unwanted results (ICAN study pack 2014) From the second definition of risk management it identifies the synergy between risk and return it could be explain further as; Safest way is not to take risk, though this is not realistic because all business activity involves risk. Business decision should focus on shareholders maximization over long time which is the main objective. Strategic

should be consistent with the amount of business risk that the company is willing to take and targets taken should be realistic for the chosen strategies. Management should try to manage the downside risks and limit business risk as strategies are implemented and objectives achieved.

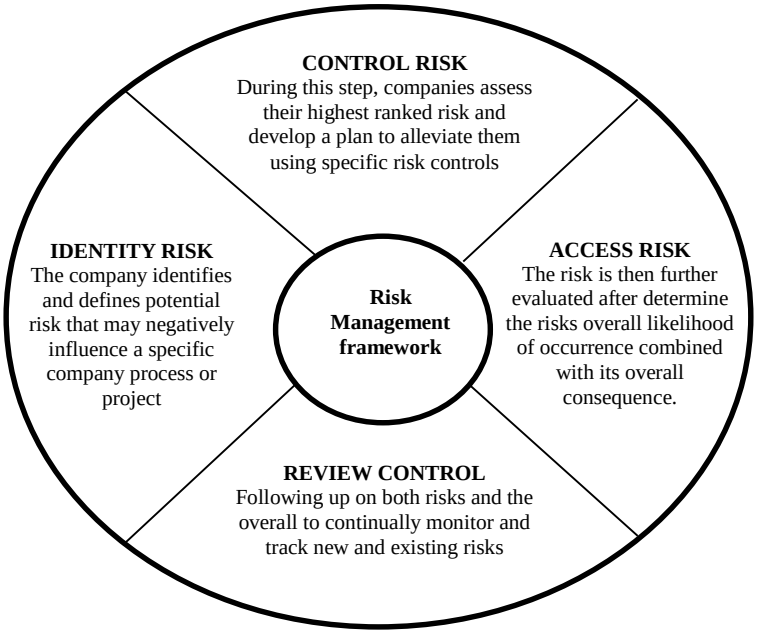

Fig. 1: Risk Management Framework (Cloudhaz 2020)

Corporate Governance and Risk Management

Risk management is a corporate governance issue. It is the responsibility of the board of directors to safeguard the assets of the company and to protect the investment of the shareholders from loss of value. They board is expected to keep strategic risk within limits that shareholders would expect, and also avoid or control operational risk. The code of corporate governance in Nigeria states that the duties of the board shall include among others, the identification of risk and monitoring of risk management systems. It also states that "the board may establish a risk management framework and the risk reward strategy determined by the board." The board is responsible for defining the company's risk policy, risk appetite and risk limits as well as ensuring that these are integrated into the day to day operations of the company's business.

Risk management and Internal Control

The Nigerian code of corporate governance states that the board should "undertake at least annually, a thorough risk assessment covering all aspects of the company's business and ensure that the company's risk management policies and practices are disclosed in the annual report. This duty is expected to be done by the risk management committee in collaboration with the audit committee and report forwarded to the board.

For example, Turnbull Guidance stated that the board should consider the following when deciding the company's policies with regard to internal control;

- The nature and extent of the risks facing the company
- The extent and categories of risk which it considers acceptable for the company.
- The likelihood that the risks will materialize

- The company's ability to reduce the probability of an adverse event occurring, or reducing the impact of an adverse event when it does occur.
- The cost of operation the controls relative to the benefits that the company expects to obtain from the control.

Types of Risk Management

Broadly speaking there are two main categories of risk. These are systematic risk and unsystematic risk. Systematic risk is the market uncertainly of an investment, it represents external factors that affects the organization. Unsystematic on the other hand refers to asset uncertainties that can affect the performance of an investment. According to Obi (2016) which opined that risk management is not about elimination of risk but how it can benefit business by creating productive opportunities, increase efficiencies in administrative system. He further stated that risk management can mean difference between success and struggle in an organization. It identified types of risk management to be:

i) Risk Avoidance: - This has to do with withdrawing from a risk scenario or deciding not to participate. These types of risk comprise of four elements;

(a) Refusal of Proposal: - If due diligence reveals the contract risk to be too high during the first stage of the contract the company simply declines the proposed contract

(b) Renegotiation: - When risk has increased in the course of the contract's life, opportunities to review and renegotiation terms may be taken to introduce new conditions to avoid new risk.

(c) Non-Renewal: - A company may decline to renew the contract if the risk is estimated as being too high.

(d) Cancellation: - where circumstances cause risk to increase beyond acceptable levels during the course of the contract life cycle and outside the renew timeframe, cancellation may be enacted.

ii) Risk Reduction: - Rest reduction technique is applied to keep risk to an acceptable level and reduce the severity of loss through.

iii) Risk Transfer: Risk can be reduced or made more acceptable if it is shared. This is accomplished through due diligence on third parties and subsequent outsourcing contracting out to another.

iv) Risk Retention: This has to do with risk that is accepted and accounted for in budgeting and its being retained. This occurs whenever an organization sign renegotiates, renews contract, there is always an element of risk retention. All active contracts represent retention of contract risk. It is therefore incumbent upon the business to incorporate this into risk management, planning, and as risk assessment processes.

By building the four types of risk management into a culture of everyday best practices, commercial enterprises send a message to third parties that they are safe to deal with. This includes customers as much as suppliers. When entities and individual know that their interests are a priority, the business benefits from repeat business and loyalty. Other types of risk management are: operational risk management, market risk, liquidity risk, interest rate risk, strategic risk, risk analysis, enterprise risk management, project risk management, financial risk management and social risk management.

Risk Assessment

Risk assessment is one of the key segments of the day by day errands of people in an organization. It is a systematic process of evaluating the potential risk that may be involved in a projected activity or understanding. All hazards of risk need to be detected and corresponding probabilities and consequences need to be analyzed. The decision must be made

on whether the risk is acceptable or unacceptable. If the risk is acceptable, the appropriate risk mitigation must not be undertaken. Regular review and monitoring are required to ensure the effectiveness of the implemented action. However according to (Sirha 2019.) risk could be assessed using the following steps;

Step 1: Identify the risk: - To avoid risk is critical, to comprehend what will turn out bad as well as know why it might be bad. Hazard can be distinguished by utilizing a few unique methods, for example walking round the working environment, asking your representative check the manufacture information sheet or accident books. If a longer time is taken to identify all hazard created then the cost of developing the management process will be higher than the early hazard identification.

Step 2: Decide who might be harmed: - when you have distinguished the various hazards, you have to comprehend who may be hurt and how, for example individual working in the warehouse where there are fumes. Always consider the workers or operators, visitors and other occupants

Step 3: Evaluate the risk and decide on the precaution: - After identifying the risk and who might be harmed its necessary to evaluate on the necessary precautionary measures to be adopted. The risk could either be removed completely or controlled. In order to reduce the consequence of the risk, initially it is required to prevent access to hazard, organize to work to reduce exposure, issuing protective equipment and welfare facilities.

Step 4: Record the findings and put them into place: - your finding should be written down. These records should include details of any hazard noted in the risk assessment and action taken to reduce or eliminate the risk. It serves as an evidence that assessment was carried out and is used as basic for later renew and it's a working document for the management of an organization.

Step 5: Renew of risk assessment: - Risk assessment should be reviewed. If there is any significant change or if there is any improvement that still need to be made if the proposed actions generate new hazards. (Sirha 2019). Risk assessment is sometimes called risk profiling or risk mapping. Risk map help identify risk where immediate control measures are required and where the need for control measures should be considered or reviewed periodically. It is vital that companies' asses risk on an ongoing basis for immediate response.

Measuring Risk: Risk measuring means quantifying the risk, risk quantified are easily managed through setting target for maximum risk tolerance. However initial risks can be measured. When risk is assessed qualitatively and risk management decision becomes a matter of management judgment.

Prioritizing Risk: This refers to when organizations need to establish a process for deciding which risks are tolerable and which might need more control measures to reduce risk. Deciding a priority for risk management might be a matter of management judgment. Some companies use formal techniques to help them with the prioritization of risk eg is the risk dashboard.

Risk dashboard is used to identify which risks needs further control also it is a panel that shows the status of organization key performance indicator and helps monitor the progress of improvement in an organization which in turn will assist in decision making. (Amin, Valverde and Talla 2020)

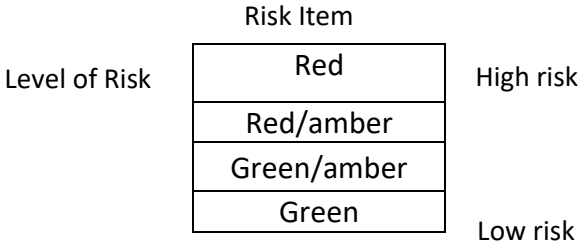

Fig. 2: Risk dashboard (ICAN 2014)

Fig. 2 represents a simple dashboard used by management in risk assessment. Each risk is being identified and represented by a coloured light. The colours as shown in the diagram are usually green, amber and red. A risk that shows red light indicates that further risk measures are needed, a green light indicator means that the risk is under control an amber light indicator means that the risk needs to be kept under review with all these a risk dashboard helps identify vulnerabilities, gaps and opportunities from different viewpoint in an organization. It also helps manage and mitigate against any potential business risk by providing quantities and qualitative indicator of systematic risk in an organization.

Role of Board of Directors in Risk Management

Risk management is largely a responsibility for management to oversee and manage risk. Harsh economic times hit boards of directors squarely as they come face to face with complex legal issues and failing businesses. Financial downfall along with the subsequent fallout was an abrupt wake up call for boards of directors to delve deeper into their organization risk management practices. The following are some of the board roles in risk assessment;

(a) Monitoring: The board should help management establish testing and evaluation procedures to monitor the company's risk management system. Modification to risk management system should be made as needed in response to these evaluations.

(b) Information and communication: Relevant information should be well documented and communicated on timely basis, vertically up and down the chain of management and horizontally across division of a company to ensure that all members of the organization carry out their responsibilities with respect to the company's risk management polices (Dortch and Davis 2005)

(c) They are responsible for assessing risk and for designing and implementing risk controls.

(d) They are charged with giving clear guidance about the company's risk appetite.

(e) According to UK corporate governance code, the board shall review at least once a year of the effectiveness of internal controls and this include the effectiveness of risk management systems.

(f) Duty to report to shareholder on its reviewed internal control measures.

According to Dortch and Davis (2005), the boards role in risk management may be further explained using the eight components of Enterprises Risk Management Integrated framework (ERM) which are i) **Internal environment:** The tone of an organization is set by its leaders. Does the company have a large appetite for risk or are its leader more risk averse? Does the company's culture support the risk management and internal controls process? **ii) Objective Setting:** A company may set goals on many levels; strategic operating, financial. By clearly identifying its goals management and the board can clearly perceive the risk that the company may encounter.

i. **Event Identification**: The board should ask management how the company identifies new risk and opportunities, what risk and trends exist, what risk are associated with new products, services or acquisition who interrelated are they. All these are roles to be played by the board.
ii. **Risk Assessment**: After identifying potential risk, the board should analyze and prioritize the risk in light of their likelihood and potential impact.
iii. **Risk Response**: The board may choose to respond to risks by avoiding them, accepting, working to reduce their impact or dilute their severity by sharing with other parties. Some questions raised by the board are what are the cost of these alternatives? Has management allocated sufficient resources to respond appropriately?
iv. **Control activities**: The board should work with management to develop and implement well-structured policies and procedures in response to the company's primary risk to ensure that response actions are carried out at all levels of the company.
v. **Information and communication:** The board ensures that information is well documented and communication is on timely basis to enable members can out their responsibility with respect to organization's risk management policies.
vi. **Monitoring:** The board should help management establish testing and evaluation procedures to monitor the company's risk management system.

Board committees should incorporate risk management into their regular responsibilities (Dortch and Davis, 2005).

Risk Disclosure and Corporate Governance

Miihkinen (2010) explained risk disclosure as information that describes firm's major risk and their expected economic impact on their current and further performance. Corporate disclosure comprises the communication of information by corporate insiders such as management and entrepreneurs to stakeholders of a company. The main audience is equity and debt capital providers, but also includes other stakeholders such as policy makers, regulatory bodies, tax authorities, employees and general society. Certain disclosures are mandated and others are voluntary. Mandatory disclosures include financial reports whose extent and comprehensiveness in part depends on whether the disclosing company is listed on a stock exchange and on the size of its listing. In addition to mandatory reports voluntary disclosure have become an important frequent way for organizations to disclose their financial performance and communicate the stewardships available resources, such disclosures include conference calls, management forecast, sustainability reports and online earnings guidance and information sharing. Disclosing of information can be costly, however, companies disclose private information only when the perceived benefits exceed the associated direct and indirect cost of disclosure.

However, risk measurement plays a central role in capital allocation decision, investors allocate capital to investment opportunities that provide the highest expected return for a given risk level. Access to information is critical for investors to assess the expected risk and return of investment opportunities and make investment decision.

According to Hope *et al*., (2016), they opined that corporate disclosure has to do with understanding the motivations for disclosure and consideration attentions attached. Though there is no single theory available to explain disclosure phenomenon completely. Linsley and shrives (2000) suggest that some theories such as agency theories, signaling theory, stakeholder's theory, capital need theory, benefit cost theory could be relevant for motivation of risk disclosure. Risk disclosures

reduces the variance uncertainty premium and thus the expected cost of capital while also affecting users of financial statement.

Risk Management Challenges

Some challenges associated with risk management are: i) Lack of a common definition of critical risk terms, ii) lack of cultural or context understanding of the organization, function, or process being risk assessed iii) lack of executive management support for the risk assessment. Iv) Failure to take known risk into account, v) failure in communicating risk to top management vi) Failure in monitoring and managing risk vi) failure to use the appropriate risk metrics. These problems in risk management practice confirms that risk management is a complex system. It can be a very effective tool, but risk managers and management should be aware of the potential failures (Stulz 2018).

Conclusion and Recommendation

Risk assessment is structured so that business managers only capture the known risk. However, in many cases its unknown risk that contributes and facilitates risk assessments there is need to learn the various risk faced by an organization and how to assess them in order to handle the risk effectively. The board in discharging its role must be vested with risk management procedures and ensure that the ERM model is strictly adopted by the board of any organization. It is therefore recommended that effective corporate governance will help in effective risk management procedure.

In Nigeria today, it is common for organizations to ignore some risk due to poor corporate governance hence this would affect the shareholder, policy makers, investors as regulatory guidelines on risk management are being mitigated. The regulatory structure should be implemented efficiently and effectively to help reduce risk to its bearest minimum. Also, board should ensure that a broad-based view of corporate governance which includes totality of their role is encouraged and corporate governance codes be maintained

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Developing Political Consciousness In Nigeria To Answer The Leadership Question: 1960-2015

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Abstract: *A careful review of political life in Nigeria would reveal that what has been emphasized has been political participation not political consciousness. As a result, the same unbalanced ideologies and way of doing things have been handed down from generation to generation. It is often stated that people get the leaders they deserve. That statement seems to hold true for Nigeria as corrupt, unruly, wasteful and high-handed behavior can be discerned both in the Local Government Clerk and the Federal Government Permanent Secretary. This is in stark contrast to admirable good governance practices seen in Europe and Asia. For the fickle minded and faint-hearted young Nigerian of means in the 21st Century, the solution seems to be immigration to these choice locations. The laws governing human rights allow for freedom of movement. The mass Exodus from Nigeria to countries in Europe, Asia and North America has however been done in a ridiculous, condescending manner that suggests that the Young people leaving are not part of the Nigerian problem. What is interesting to note is that many Nigerians who constituted a public nuisance while living in Nigeria are suddenly capable of diligent productive behavior in the Countries where they now reside. Investigation into this immigration phenomenon makes two things readily obvious. First, genuine change in personal and national life is possible if the right enablers are provided. Second, the unchecked flaws and excesses of the Nigerian political elite have subtly provided a license for reckless behavior to the whole Country. Mass Media and historical discourse have shown how these towering heights were achieved by the Countries in the West. Thus. acts of resignation by Nigerians and indeed a number of countries in Black Africa have only suggested to uninformed that perhaps some races in the world have capabilities that others do not.*

Keywords: Race, Hamitic Hypotheses, Immigration, Politics, Leadership.

CITATION:

Essien, U. J. and Edemekong, N. D.(2023). Developing Political Consciousness in Nigeria to Answer the Leadership Question: 1960-2015. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 453-461

Introduction

Accordint to Uya, (2009) when discussing the hamitic hypothesis in historical discourse reference is often made to the statement by Hugh Trevor Roper when asked by his students to take them on a course in African History. Trevor Roper responded, "for now there is nothing that can be called African History, maybe in future there will be, but for now there is nothing, and all that exists of African History are the exploits of Europeans on the continent, the rest is darkness and darkness is not a subject of history". The hamitic hypothesis is linked to the story of how Noah cursed his son Ham for staring on his nakedness while he lay drunk on his bed. The hypothesis suggests that Black Africans are the descendants of Ham and because of the curse of Noah are incapable of productive development without external assistance. This theory was met with stiff resistance by African scholars from the 60's to 80's as they expressed in writing that Africans

were bold intelligent people capable of progress and productivity. This progress and productivity has been expressed by the black community in many western climes. Indeed, a Black African of Kenyan extraction by name Barack Obama has risen to become an outstanding President of the United States of America.

On the Continent however there is a serious deficit in the pool of people that perennially present themselves for leadership positions. Those that are usually available to be voted for in Nigeria for instance are sometimes notorious criminals, retired military personnel or people of questionable wealth who have the resources and means to fund and sustain a political structure. In answering the paradox of the leadership question in Nigeria, certain questions must be asked. First, how did a system that encourages people of questionable character and competence evolve and emerge? To answer this question, a cursory look must be given to Pre-colonial and Colonial history. It is often state stated by dependency theorists like Daniel Offiong and Walter Rodney that the seeds of the pervasive enshrined corrupt practices that dominate the continent were sown in the long brutal years of imperialism, slavery and colonialism. Everything was calculated towards profit and exploitation in this period and a base corrupt nature was one of the unforeseen and unintended consequences of this period of exploitation. Thus while things were done with Machiavelian brutality on the African continent a semblance of normalcy was maintained in the Imperial home country.

Second question to be asked in resolving the Nigerian leadership Paradox is why such a destructive system is continually eulogized, promoted and nourished even in the twenty first century? The answer is not farfetched. For the commoner or person of simple parentage survival is often tied to an unbalanced political patronage system. In almost every Village, clan and local government in Nigeria there are usually a number of stand-out people of wealth and influence and for the commoner progress in life is often tied to humble submission and exaggerated dramatic loyalty.

The third reason why this system seems to be adored and encouraged even by those who should know better is that it is rotational. The Nigerian political system gives access to high velocity wealth, influence and power. Thus, instead of discouraging the system because of its big picture detrimental consequences the unbalanced system is encouraged by a narrow-minded consolation and attitude of one day it shall be our turn

In an academic discourse it is not enough to elaborate on the reasons for a problem, ways must be suggested on how that problem can be solved. One of the ways of solving the leadership paradox in Nigeria is exposing and discouraging corrupt practices in the Country. Corruption in the Nigerian context can be described as a monster that destroys everything good and useful in the Country. Nigeria a country blessed with abundance of human and natural resources is a laughing stock in the comity of nations because of her perpetual dependence on countries in the West. Incidentally, a number of Countries in black Africa are making bold attempts to answer their leadership questions. Rwanda is a good example in this regard. Under the able leadership of Paul Kagame, Rwanda has been transformed into a vibrant industrial and economic hub in Africa.

A lesson that can be learnt from the Rwanda story and that can serve as a panacea for the depilating Nigerian situation is that there has to be serious discontent by the general populace before true visionary leadership can emerge. According to Owen and Usman, (2015) there was a semblance of this discontent in 2015 where across the Country people protested against reports of staggering corruption in the Dr. Goodluck Ebele Jonathan regime. What fuelled the discontent towards the 2015 general

election was the seeming helplessness and resignation by President Jonathan famous expressed at a rally where he described and likened fighting corruption to leaving a goat with a yam. The goat in this instance would be corruption and the Yam would be government resources. What the President of the Federal Republic suggested perhaps in an absent-minded state that pilfering government resources was too exciting a proposition to be turned down by Nigerian government officials. It cost him the general election. Perhaps what he was trying to communicate was that his hands were tied by a brutal corrupt cabal that had been instrumental to his rise to office.

President Muhammed Buhari and his campaign team were strategic enough to seize the moment as they sold themselves as honest, diligent, people that would set things right. Vice President Yemi Osinbanjo was sought out and persuaded to run as Vice President because of what he stands for and represents. Constant reference was also made to President's Buhari's famous clamp down against indiscipline and corruption in the 80's when he was Military President. It was obvious as the election drew near that there was a hunger and a longing for a return to such disciplined, controlled and regimented living. Research and feedback by the authors of this paper indicate that the pre 2015 general election expectations of Nigerians have not been met quiet. There is however gentle and quiet consolation that things are no longer done with open profligacy.

Developing Political Consciousness in Nigeria

As earlier enunciated in this work, the emphasis by the Nigerian government especially through agencies like the National Orientation Agency (NOA) has been political involvement and participation rather than political consciousness. It is possible to be involved in something without being conscious of what you are doing. Britain for instance is a very politically conscious society. That is why sitting members of parliament can be impeached and jailed for taking vacations withy government funds. Such an offence would however not stir the hornet's nest in Nigeria but would rather be viewed by political acolytes as a show of wit.

What then is the way out of this dangerous political apathy? One of the proven ways of solving the problem is through concise, well-articulated, meaningful education. The University of Calabar, Calabar, Cross River State has as its motto, Knowledge for Service. The intention of those at the helm of affairs of the University is to equip its graduates with knowledge to serve in every sphere of life. This can be viewed as the subconscious goal of every educational establishment in the Country. Sadly, a meaningful number of Nigerian graduates from Universities that cut across the country have clearly demonstrated when given the opportunity that they lack the means and capacity to serve. Reviews by educational consultants have indicated that there are gaps in the Nigerian educational system as it exists today. Perhaps this is one of the reasons there is very little original technological innovation in the Country today. It is important to note that most members of the Nigerian political elite and most people of means still prefer to send their children to foreign Universities in Europe, Asia and the United States of America. This should leave room for concern. If their children who are one of their primary concerns are guaranteed quality education outside the Country, what then will provide the impetus for much needed educational reform in Nigeria?

According to Nwokocha, (2016) any careful review of the educational process in the country would indicate that the unintended emphasis seems to be on memory retention rather than cognition and understanding. Thus, many at times the highest scores go to the students with the strongest "cramming" ability or those who can best replicate what is contained in the reading materials. Such a learning environment

does not breed people who are politically conscious and can be likened to a garbage in garbage out computer interface. A politically conscious person who has fully developed thinking capabilities is able to identify items in the news, newspapers, government gazettes and bills that violate public trust and take concerted action with other well-meaning members of the public to set things right. When the general populace is not afforded rigorous quality education, it is easy for the populace to be fooled by propaganda and other such gimmicks of the government's media wing.

It is thus the sincere desire of the researchers that worked on this paper that the information collected and interpreted in this paper would provide impetus for educational reform. Proper education would in turn provide an enabling environment for the development of a politically conscious populace. This is would subsequently and consequently pave the way for the leadership question that bedeviled the Nigerian nation for years to be answered. Education is thus vital in raising a politically conscious people.

The Leadership Question in Nigeria

According to John .C. Maxwell the internationally acclaimed leadership expert, everything rises and falls on leadership. This has been the case with in Nigeria. Nigeria's present state of affairs especially in relation or comparism with other Countries in Africa and the world at large has largely been determined by her leaders. This is so because it is the leaders that make and execute the important decisions that determines a nation's state of affairs. While Nigeria has had bold strong an even vicious leaders, she is yet to produce a leader in the stature of a Winston Churchill or a Nelson Mandela who would galvanize the nation by the strength of his character and with a strong hand thrust the nation towards the Promised Land. A lot of the national leaders in Nigeria when they emerged were heralded as the long-awaited messiah that would push the nation out of the throes of a dark and difficult past. These leaders however, despite their promise relapsed into old familiar behavior that included Corruption, graft, nepotism, embezzlement, acting with impunity, poorly thought out white elephant projects geared towards embezzling the treasury and a callous disregard for the sanctity of human life.

Monday, (2020) it must however be noted that despite their shortcomings most Nigerian leaders met the demand of the time. There thus seemed to be an adequate leader for every season and dispensation. One thing Nigeria has never been short off right from independence is credible competent hands. This is one of the reasons why her leadership question seems to be a paradox of sorts. The question that is often asked is why these credible competent hands do not make into high office and this question has been adequately answered in the earlier portions of this research undertaking. During President Olusegun Obasanjo's civilian administration he gathered a crack economic team that included the likes of Professor Charles Soludo, Dr. Ngozi Okonjo Iweala, Obiageli Ezekwisili, Malam Nuhu Ribadu and others. It is important to note that the pedigree and competence of this crack economic team was interpreted by the international community as a firm commitment towards excellence and played a critical role in securing the landmark Paris Club Debt Relief deal.

A number of these crack economic teams have vied for the Presidency of the Country. The political narrative however when these calibers of people have vied for President is that they do not have structures. It is however interesting to note that Professor Charles Soludo has emerged as Executive Governor of Anambra State after a brilliant impactful stint as the Governor of the Central Bank. This is a clear indication that Nigeria is slowly demanding a new crop of people as its leaders.

The involvement of the electorate in participating in and monitoring the 2015 election

is a clear indication that the general populace is slowly but unerringly making room for the kind of leaders they want to slowly but steadily emerge. In that election, most people used their mobile phones as on-site cameras, manually tabulated and verified the results and used social media to protest against discrepancies between Pooling Booth results and announced results. Social Media sites proved to be a veritable tool during that election and the change mantra of the All Peoples Congress was spread to all who would care to listen. The bubble on social media and general discontent with corruption indices created a tidal wave on Social Media that led to the emergence of President Muhammad Buhari as President. When making reference to the 2015 election it is always important to point out that President Buhari victory was against an incumbent President. This is an outcome that rarely takes place in Nigerian Elections.

In demanding for President Muhammad Buhari, the electorate had certain expectations. The Country yearned for a firm, resolute and resilient leader who had a zero tolerance for corruption. This can thus be seen as an acknowledgement of the fact that corruption remains the main cancerous malaise that hinders the progress of the nation. The search for and demand for President Buhari in the 2015 Election can thus be seen as one of the most forthright attempts by the Nigerian populace to answer the leadership question that bedevils the nation. It represents a deliberate attempt to seek out an individual who could fill an existing leadership gap. The determination of the general populace ensured that their wish was granted and set an interesting precedent for future general elections.

Prior to the Fourth Republic, Nigeria's leadership needs tended to be met by members of the Nigerian Armed Forces. Men in Uniform led the Country for a significant number of years and in their own way they provided significant leadership. It is important to note that at times in Nigeria's political history, Military leadership was actually sought out and demanded for. According to Bassey (2005) the Nigerian Military is a colonial legacy. Bassey adds that tracing the origin and development of the Nigerian Military is like tracing the history of British colonization in Nigeria. Bassey proceeds in his work to discuss three theories that explain Military intervention in Nigeria. The first theory is labelled "the internal characteristics" model. This theory was propounded by Morris Janowitz. According to him, military intervention could be explained in terms of internal structure of the military including the social background of officers, the skill structure and career lines, internal social cohesion and cleavages, professional and political ideology.

The second model was propounded by Samuel Huntington who emphasizes that the most important causes of military intervention in politics are not military but political. Huntington contends that societies where most social forces are and institutions are highly politicized usually have political clergy, political universities, political bureaucracies, political labour unions, political corporations, and of course political armed forces. Accordingly, all these political bodies including the military tend to seek political relevance in order to protect their corporate interests.

The third model or theory is propounded by John Dallard and it is labelled the "frustration-aggression model" The fundamental thesis of this theory as propounded by Dallard is that "the occurrence of aggressive behavior always presupposes the existence of frustration and contrariwise the existence of frustration leads to some form of aggression. Collective frustration arises principally from the inability of the political system to satisfy or guarantee the attainment and maintenance of social goals, aspirations and values of the people.

In the Nigerian scenario it can be stated that it was a combination of these three factors that

led to frequent disruptions of political rule. The Military in Nigeria ruled by decrees and executive fiat and in most cases were able to get things done with greater speed, scale and intensity. There was also a greater sense of order during the Military regimes as it was acknowledged by the general populace that deviant action would be met with brute force. The Military however, had a poor human rights record and tended to introduce a culture of impunity. Decisions were of often take due consultation and at time even with the disapproval of the general populace unfriendly and unreasonable decisions were still taken.

It is important to note and observe that in the Fourth Republic with an avowed end to Military rule, retired Military Generals were still sought out and supported to run as Civilian Presidents. Notable in this regard are President Olusegun Obasanjo and President Muhammed Buhari. This is testament to the strength of the Military institution in Nigeria and an indication that good Military training can prepare a leader for effective political life. This strand of thought is seen throughout ancient history with leaders like Alexander the Great of Macedonia receiving tough Military training as a preparation for leadership. In modern times there is the example of the leader of Dubai in the United Arab Emirates Sheikh Mohahmed Bin Rasheed Al Maktoum who received Military training at the prestigious Sandhurst Military Academy in the United Kingdom and returned to implement ground breaking developmental strides and reform in Dubai. In England the two crown Princes, Prince William and Prince Harry have both offered Military service to the Kingdom and Prince Harry notably had to be whisked away from Afghanistan when it was discovered that he was involved in live combat and might become a high bounty target.

Closer to home, Governor Udom Emmanuel of Akwa Ibom State in Nigeria in one of his deliberations with a High ranked Air force Service Chief notably requested for an Airforce Base for his State providing an added incentive for approval by stating that he would provide land for that purpose. Such a facility if eventually approved would provide employment, added security cover for the Akwa Ibom People, Protection of treasured Oil installations and the Coast line, and additional and alternative landing strip to the Victor Attah International Airport, Much needed training for the Country's teeming and talented manpower and a strategic boost to the Nigerian Armed Forces.

Providing Food Security in Nigeria

There are many areas of discourse that deserve academic deliberation with regards to the leadership question in Nigeria and the yearnings and demands of the Nigerian people. However, because of the unique peculiarities of this academic paper, food security has been chosen as an obvious topic for discourse. The question must then be asked what Food Security is and why is it important to a nation? Food Security in the context addressed in this publication in simple terms can be seen as a situation where a Nation can meet its basic food needs without much or significant external assistance. It is important to a nation because when a Country cannot meet its basic food or dietary needs in the event of a conflict or hostilities it easily capitulates in a conflict.

There is a record in the Bible, the Holy Book of Christians that perhaps clearly depicts the grave danger in the lack of food security. In 2 Kings Ch. 7 Vs. 24-33 the nation of Israel was besieged by the Syrians and the attendant consequence was that food became too expensive to buy. Such was the severity of the reported siege that people descended to cannibalism, cooking their children in turn to meet their dietary requirements. This ancient story has many lessons. Not only is it important to produce food, it is also important to provide some security cover for Agricultural installations. This is because the siege still remains a principle

of modern warfare as can be seen in the ongoing conflict (2022-2023) between Russia and Ukraine.

What is disturbing about the Nigerian context is that almost every basic food category is now being imported as processed food from Europe, Asia and America. The food security implications are that when the dependence is full blown it can become a dangerous tool of manipulation in the hands of these foreign benefactors. This would thus not only have National security implications but grave Foreign Policy implications. There is thus a need for the Federal Government of Nigeria to show genuine concerted political will in ensuring that the nation attains a reasonable and sustainable level of Food Security. This would ensure that certain vital National security variables are in the Nation's hand. Apart from Security implications there are also grand micro-economic and macro-economic benefits to be derived from running a nation that is Food sufficient. There would positive outcomes on the nation's Gross Domestic Product (GDP), less likelihood of large-scale food poisoning, a promotion of Agro-Technology that encourages the production of a large number of by-products, more opportunities and a greater number of available jobs. Largely because of corrupt practices and a lack of firm political will the Agricultural sector in Nigeria is generally regarded as a graft waste pipe. This is so because despite the stupendous amounts of money running into billions of naira perennially allocated to that sector there is very little to show in terms of Agricultural output. Thus, while there is a general acknowledgement in government circles that Agriculture holds the key to a prosperous independent Nigeria there is very little commitment to do the right thing. In any organization, institution or nation commitment runs from the top down. It is stated as a graphic example in motivational speaking circles that an army of sheep led by a lion would always defeat an army of lions if they are led by a sheep. Thus, while the lion leader would spread courage, boldness and fearlessness, all qualities of a lion to his army of sheep, the sheep leader would on the other hand fear, indecision and timidity to his army of lions. Everything rises and falls on leadership.

It is not enough in any academic discourse to rigorously brainstorm on a problem, firm, practical and pragmatic solutions must also be proffered. The country's leadership must show a firm, sincere commitment to seeing that Nigeria as a nation attains a significant level of food security. Pragmatic agricultural policies should as a matter of urgency be implemented as this would have the consequential effect of lifting the general standard of living. When genuine commitment is seen by the nation's leadership in lifting the agricultural sector from the doldrums the same commitment would invariably be replicated by the general populace.

The Demand for Good Governance in Nigeria

It is on record and can be stated that from onward Nigerian have developed progressively the ability to hold their leaders to account. There have been all sorts of mass protests from the "Occupy Nigeria" protests that protested against impunity in the Goodluck Ebele Jonathan Administration to the "EndSARS" protests that that sought to magnify and kick against the excesses of the special anti-robbery squad of the Nigerian Police Force (NPF). Nigerians in the 21st have used all available channels to insist on and demand for good governance. The demand is yielding positive results as establishments and institutions in the country are evolving positively. It is often the comment of the sincere Nigerian on the street that illegal activities that were previously possible are no longer possible in today's Nigeria. There is mass upgrade and innovation in Banking, Immigration, Food and Drug Control, Medicine, Academics, Security Management, Law and Commerce. While the country is not yet in the Promised Land, there is

significant and commendable progress that causes the common man to be encouraged.

A number of noteworthy organizations have developed and evolved in the country and these organizations have made life safer and better for Nigerians. Significant in this regard are the National Drug Law Enforcement Agency (NDLEA) National Agency for Food Drug Administration Control (NAFDAC), National Identity Management Commission (NIMC), Standards Organization of Nigeria (SON), Economic and Financial Crimes Commission (EFCC) and Independent Corrupt Practices Commission (ICPC). These agencies are all government initiative backed by legislation usually out of a demand for good governance.

One of the ways the average Nigerian has made his voice heard in the 21st century has been through the use of social media. Two giant social media companies have made this possible. They are FACEBOOK and Twitter. Whatever is posted or tweeted on social media handles is available to an incredible amount of readers and indeed the whole world hence the appendage for the internet; world wide web. These social media accounts are free, easy to use, easy to open and engage and available to any above 18 who has internet access. Social media played a critical role in the Nigerian 2015 general election as a mass army of individuals now casually referred to as social media influencers thronged to the internet to disparage the incumbent Dr. Goodluck Ebele Jonathan administration. Such was the monstrous impact of Social media during the 2015 election that today it is the odd Nigerian politician that does not have a social media handle where he communicates with his followers.

There has also been a marked improvement in the quality of legislation afforded Nigerians at all level. The three main arms of government in Nigeria are the Executive, the Legislature and the Judiciary. Power resides with the executive while the legislature and judiciary provide much needed checks and balances. A landmark victory for the Nigerian legislature in the Fourth Republic was when in his second term (2003-2007) President Olusegun Obasanjo, a strong willed and vibrant leader felt that to complete his significant agenda he needed to extend his tenure beyond the mandatory two terms to three terms. Despite many subtle overtures by the executive it was firmly resisted by the legislature and can be recorded as a landmark victory for democracy in the Country. There have also been marked efforts by the Nigerian government through the Nigerian Broadcast Corporation (NBC) to take parliament practice to the next level. There is currently a dedicated channel called NTA parliament committed to broadcasting the activities of the Federal Legislature, the Senate and the House of representatives. It is thus easier for the average Nigerian to monitor and track the activities of their elected representatives in the legislative arm of government.

Conclusion

It can thus be stated that the deficit in leadership in Nigeria and indeed in Africa in the post-colonial era has often helped to enforce negative stereotypes like the hamitic hypothesis. The thoughtless, self-centered actions of a number of African leaders have often led the early proponents of this racist Eurocentric theories to feel that their ideas had merit. While these theories were countered and resisted especially by African historians the actions and inactions of African leaders did little to assuage the racial theorists. In the 21st century a new disturbing trend seems to be emerging. Nigeria's younger working-class generation 25-45 years of age instead of rolling up their sleeves and committing to build the nation of their birth are rather committed to immigrating to Europe, the Carribean, North America and Asia. These countries on the other hand have set out stringent immigration laws that aids them sift out the very best Nigerian professionals. It can

thus be stated with veritable proof that a generation seems to be emerging in Nigeria that does not believe in their country. It can be concluded that despite a gamut of arguments in writing and a multiplicity of arguments on broadcast media, the Nigerian State is slowly but progressively answering its leadership question. An appropriate leader has tended to emerge at every stage in her development and evolution and specific reference is made to the 2015 general election where a specific leader was sought out to meet the exigencies of the moment. The political structures and indeed the process is slowly but surely evolving and there seems to be a demand for a new crop of leaders who are selfless and whole heartedly committed to the cause. This paper also examined the demand for good governance in Nigeria stating that the demand for good, equitable and accountable governance is progressively getting stronger. This demand must not only be encouraged, it must be fed and nourished as it will help guarantee that Nigeria consistently produces leaders of the right caliber. Finally, this paper made a case for a commitment to attaining significant and reasonable food security. It was ascertained that attaining significant food security levels had serious diplomatic and national security implications.

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Improving Food Safety And Security Through Value Chain Management And Safety Regulation In Informal Food Sector In Nigeria

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Abstract: *Food safety presents a vital public health challenge globally, particularly in emerging and developing countries. It has also become one of the most serious social problems that need to be addressed in most low- to middle-income countries, including Nigeria. The informal food sector remains an important component of urban and semi- urban food supply system and plays a fundamental role in ensuring access to food by the urban poor. Implementation of food safety protocols in the informal sector has traditionally focused on enforcement strategies to remove implicated food from the market. This reactive approach has neither prevented nor alleviated the rising cases of foodborne illnesses in the society and hence a more coordinated and integrated approach aimed at eradicating the menace is imperative. Food chain approach to food safety acknowledges that the responsibility to provide safe, healthy and nutritious food lies with all the actors taking part in the production, processing, trade and consumption of food along the entire value chain. This responsibility extends to the end-user who must be educated to ensure that food is properly stored, hygienically prepared and food shelf lives are respected. Government departments with mandates to render public health services are also implicated in this regard. The food chain approach uses a systematic approach known as the Hazard Analysis and Critical Control Points (HACCP) to identify, assess and control hazards during production, processing, manufacturing and preparation of food. The complexity of food value management, poor traceability and diversity of human behaviour are some of the challenges facing the effective value chain management and safety regulation in the informal sector.*

Keywords: Informal food, value chain, food safety, food security, Nigeria

CITATION:
Ukwo, S. P. and Ndaeyo, N. U.(2023). Improving Food Safety and Security Through Value Chain Management and Safety Regulation in Informal Food Sector in Nigeria. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 437-454

Introduction

The informal food sector is an important component of urban food supply systems and plays a significant role in ensuring access to food by the urban poor. Yet, policy frameworks both to address food security and govern the informal sector is significantly neglected, poorly understood and where policies do exist, they are not implemented and enforced (Skinner and Haysom, 2016). The inability of the formal agri-business to dominate the production, processing, retailing and marketing of food in Nigeria and other developing economies; have given the informal food sector the opportunity to thrive with considerable resilience. Despite the existence of supermarkets and shopping complexes in major cities, they remain a tiny minority of all food retail outlets, the vast

majority of which operate in the informal food economy (Greenberg, 2010).

Food supply and distribution, getting food from producer to urban consumer, involves a number of activities: assembling, handling, processing, packaging, transport, storage, wholesaling, and retailing. Inefficiencies in these areas have led to safety issues, higher prices, if not food shortages (FAO, 2007). The role of the public sector is increasingly reduced and consists mainly of provision of infrastructure including roads, storage facilities and public markets and setting of market rules and regulations as well as control of food quality (Aragrande and Argenti, 2001). In Africa, some urban informal food sellers exchange transformed products for unprocessed agricultural products with relatives in the countryside. However, this is only a relatively minor part of food distribution, but may represent up to 7% of the food brought into African cities (Egounlety, 1997). Although the informal transport sector is understudied, it is an important part of food supply and distribution throughout the world and in cities of all sizes. A study of informal food transport by Wilhelm (1997) in Africa showed that most foods, even that traded in the formal sector, are transported to cities through informal means of transport.

Informal transporters use many means of transport including non-motorized vehicles (bicycles, manual carts and rickshaws, and animal-driven carts). Where short distances are involved, porterage (walking) is also common, although women carry lighter loads than men. Various forms of motorized taxis and public transport are also used to carry food items to market. Due to higher fuel costs globally, non-motorized forms of transport are unlikely to disappear, and in fact should be encouraged. In many places, however, authorities view informal transport providers as remnants of tradition and do not pay enough attention to the sector (Wilhelm, 1997).

Food safety has traditionally focused on enforcement mechanisms to remove unsafe food from the market, instead of a more pronounced mandate for the prevention of food safety problems (Bukalewa, 2020). Generally, the orientation of many food safety systems tends to be reactive and defined by enforcement criteria instead of being preventive and holistic in the approach to risk assessment and reduction (Skinner and Haysom, 2016). It becomes imperative that integrated strategies for reducing the most significant risks throughout the entire food chain should be incorporated into any revised strategic direction in food safety systems. Such systems in both developed and developing countries are under unprecedented challenges, arising from demographic change, shifts in food consumption patterns, increased urbanisation, more intensified food production techniques and the need to adapt new technologies (Ukwo, 2022). The globalisation of international trade in food, as well as food safety standards, is an additional and overriding challenge to these systems (FAO, 2007). The implementation of food safety in the informal sector need to go beyond the traditionally focus of enforcement mechanisms to remove “unsafe” food from the market (Bukalewa, 2020), because this reactive approach, which is also a response to other non-compliances of the sector to tax evasion, trespassing on private land and traffic congestion mainly targets street vendors and typically involves issuing of fines, making of arrests, confiscation of merchandise, demolishing of market stalls and other measures have often fallen short of meeting the safety need and guarantee the quality of informal food (Glatzel, 2017).

The focus of the research on informal foods sector is to stimulate conversation towards the implementation of safety protocols along food

value chain in the informal sector The current food safety regulation have somehow fails to hold producers (including urban and peri-urban agriculturalists), transporters, processors, managers, small restaurant owners, members of cooperatives among others accountable as these stakeholders also have a role to play in ensuring the production, processing, packaging and distribution of safe food Before now, such efforts have been rendered ineffective due to lack of deliberate involvement of relevant stakeholders involved in food supply chain (Resnick, 2017). The study also illustrates the relevance and the applicability of a food chain management approach in the implementation of food safety regulations in the informal food sector of Nigerian economy. This study is meant to assist relevant stakeholders involve in food value chain, improve and strengthen the food supply and distribution systems in Nigerian informal food sector with the view of improving food quality and safety thereby enhancing food security.

Significant of the Study

In all countries of the world, the urban poor and the unemployed demonstrate a strong ability to provide for their own needs and survive in difficult economic circumstances. One of their main survival strategies is what development scholars call the informal food sector (Ukwo, 2022). Their most visible activities are food production (urban, peri-urban, and rural), processing, catering and transport, and retail sale of fresh or prepared products (e.g., the sale of street food). The informal food can contribute to food security by providing small quantities of affordable food products at convenient locations for poor consumers; providing employment and income to poor households; and bringing food to marginal urban districts furthest from the city centre and the organized secondary markets. FAO (2005) defined the informal food sector to include small manufacturing enterprises and small traders and service providers as well as legal and illegal activities and a wide array of artisans. It is noted that informal food sector is often a significant producer and distributor of fresh and processed food products (including seafood and *'street'* foods) for direct consumption. According to World Health Organization (WHO) (1996), street/informal foods have an essential role for maintaining the nutritional status of the urban population as consumers demand assurance that the food they and their families are eating is safe, of good quality and nutritious food. These activities exist in urban, peri-urban and rural areas, although their relative importance in food supply and distribution activities and in local employment varies, even from one municipal district to another (Skinner and Haysom. 2016). The extent and importance of informal food sector in African cities and to African economies is often underestimated and as a result, disregarded, even trivialised (FAO/WHO, 2003). In most African cities informal sector is the 'main game in town' (Kessides, 2005). Informal sector employment comprises 69% in South Asia, 57% in East and Southeast Asia (excluding China), 53% in Sub-Saharan African, 40.0% in the Americas and Europe and Central Asia (25.1 per cent), less than half of employment is informal (Vanek *et. al*., 2014). Nigeria is famous for informal sector activities in Africa due to its enormous population of about 200 million and years of poor economic performance occasioned by alarming rate of unemployment of about 27.1% and rising poverty index of up to 40.1% (NBS, 2020). The production and consumption of foods, especially fresh produce and agro-food products, involves growing, transferring and handling food under conditions that vary considerably (Elkhishin *et al*., 2017). At any stage in the Food supply chain (FSC), if food safety is compromised, it can lead to food spoilage and microbial food contamination. In order to protect consumers from

microbiological and also chemical hazards, many countries have evaluated their current food control systems (Yang *et al*., 2012). A food safety management system, therefore, is vital for ensuring the safety and quality of foods prepared for consumers. An improvement in food safety control systems can significantly reduce microbial contamination of foods throughout the FSC (Manzini and Accorsi, 2013). Therefore, it is necessary to understand how best to manage the FSC to improve food safety and guarantee food security

Role of informal food sector in urban food security in Nigeria

-The Food and Agriculture Organisation (FAO) defined food security as a situation in which all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life (FAO, 1996). This definition covers four critical dimensions of food security: availability, accessibility, utilisation, and stability. With rapid urbanization and the challenges of structural adjustment, municipal and central governments throughout the developing world face challenges of food security. Many cities are working to create policies that will secure food production and bring safe and affordable food to urban consumers; but also contribute to environmentally sustainable development and social justice (Skinner and Haysom, 2016). With an appropriate combination of policies, public investment, and encouragement of private initiative, municipalities, central governments and international aid agencies can create healthier, safer and more livable cities. In the absence of effective policies, many countries face increasing food security problems of food contamination, land tenure conflicts, and even food riots if urban residents cannot be supplied with adequate food (FAO, 2007). The informal sector needs to be viewed as more than just an economic activity, rather informal sector enables food access, and having access to affordable and reliable food further contributes to the utilisation dimension of the FAO food security definition. Several studies interrogate the role played by informal retailers in nutrition (FAO, 2005). The Steyn *et. al*. (2013) review is a useful entry point. They drew on 23 studies, mostly conducted in Nigeria and other African countries, and assessed the daily energy intake from 'street foods'. While noting significant differences between the places, their overall review found that the daily energy intake from street foods in adults was 13%-50% and 13%-40% in children. Similarly, they found that street foods contributed significantly to daily protein intake, often at 50% of the recommended daily allowance (RDA). They concluded that street foods make a significant contribution to energy and protein intakes in developing countries and that their 'use should be encouraged', adding the caveat provided that 'they are healthy traditional foods' (Steyn *et al*., 2013). FAO (2007) summarised the role of informal food sector in urban food security as follows:

a) Easy availability of foods

- The many points of sale near to schools and offices, bus stops and stations facilitate consumer access to food, saving time and transport costs.
- Street vendors sell small units affordable to the poor.
- Traders adopt customer friendly practices to cultivate loyalty: extra portions at no charge or provision of credit.

b) Informal activities that respond to urban development and the expansion of cities

The informal food trade offers a large number of sales points in the urban districts furthest from the city center and the organized secondary markets, thus bridging the inadequacies of the formal distribution structure.

c) Informal activities that offer new services shaped by changing social patterns and dietary habits

- Street food and the sale of fresh food has served to mitigate the increasing distance between work and home.
- Some informal food traders have demonstrated a keen sense of creativity in the food products and services they offer.

The informal sector participates in urban food supply and distribution at three levels

1**.** Maintaining urban-rural links: Exchanges of food items and services within or outside the family or through direct sale by producers.

2. Intermediation: Supply and distribution of unprocessed products (transporters, retailers, including street vendors).

3. Processing and sale of ready to-eat food: Street food and small catering.

3.2 Documented Foodborne disease outbreaks associated with Informal Foods in Nigeria

In 2015, the WHO estimated that unsafe food causes one in every ten people to fall ill each year, leading to 600 million cases of foodborne-related illness and 420,000 deaths a year worldwide (WHO, 2015). In Nigeria, the challenge of unsafe food is of public health importance at the federal, state, and local government levels. There are several incidences of food safety issues resulting from poisoning and infection, due to poor food safety practices, unhygienic environments, infectious and toxic agents, are rising in Nigeria. Interestingly, the rising cases of foodborne illness in Nigeria are not only linked to the misuse and abuse of agrichemicals on agricultural products (Eziringwe, 2018), but are also related to people's poor food safety practices. A recent study also reported high levels of bacterial contamination of meat and meat products from informal markets in Kebbi and other state in Northern part of Nigeria (Yusuf *et al*., 2019). The United States Agency for International Development (USAID) is funding the Eat Safe project implementation in Northern Nigeria. The overall goal of Eat Safe is to enable lasting improvements in the safety of nutritious foods in informal markets by focusing on the consumer. The project will use an investigative approach to understand consumers' and food vendors' values, perceptions, and demand for safe, nutritious foods and the gendered roles that govern food safety related behaviors. However, some of the outstanding cases listed are highlighted by Uzoejinwa *et al*, (2016) . In April 2021, in Kano (one of the biggest commercial states in Nigeria), ten people died and a further 400 were hospitalized after drinking fruit juice that had expired over a year ago (Sahara reporter, 2021). It was believed that the incident was caused by a chemical called dansami (Sahara reporter, 2021) . This scenario highlights the poor culture of checking the "use-by" or "best before" dates of foods and ensuring that any food product beyond its "use-by" date should not be consumed, even if it looks and smells good. In March 2021, 25 people died after eating fried meat served at a bar in Alagbole-Akute, Ogun State (Olufemi 2021). Surprisingly, the deaths were classified as ritual killing and were not considered to be a food poisoning issue. The main cause of the death has not been confirmed to date. Clearly, this highlights the lack of an organized system for monitoring food safety issues in Nigeria. In November 2020, in Joi village of Plateau State, around 20 people were treated for acute gastroenteritis after taking kunu, a local drink made from millet. It was found that the grains, which were looted from a COVID-19 palliative storage unit, were bought from a petty trader in the community's market (Nation 2021). From July to August 2017, a diarrheic ailment caused by zoonotic bacteria in meat and water resulted in 62 deaths in Okoloke village, Yagba West in Kogi State, a settlement that is predominantly inhabited by Fulani herdsmen (Nation 2021). Notably, this outbreak, which was initially called "a strange disease outbreak" was eventually traced from slaughterhouses to neighborhood

food canteens, stalls of itinerant food hawkers, and standard decent eateries and restaurants in the community. Again, this scenario highlights the lack of an organized system for monitoring food safety issues, which explains the inability of authorities to ascertain the true nature of the crisis, and thus, the attribution of the deaths to a "strange disease." In February 2016, thirteen people died, while ten others were hospitalized formfood poisoning caused by *Clostridium perfringes* in Abuja Nigeria's capital. *Clostridiumm perfringes* is a bacterium that occurs in the soil and contaminates food and, subsequently, the intestinal tract of human beings (African News 2021). In July 2013, no fewer than 30 guests were hospitalized, and eight persons died after eating a suspected poisoned delicacy Ugba (an alkaline fermented African oilbean seed), in a christening ceremony in Owerri Imo State (Iyadi, 2015). On 4 June 2012, in Kafur Kastina State, 26 people comprising 20 children and six adults suffered severe gastroenteritis after consuming locally made food (Tuwo, a maize meal) prepared with treated guinea corn (Mehdizaideh *et al*., 2021). Unfortunately, this guinea corn was meant for planting and not for human consumption. Again, in one incident in 2011 in Rivers State, 112 people were reported to have been hospitalized after eating beans preserved with pesticides (Adegbola *et al*., 2011). Likewise, 120 students of a secondary school in Doma, Gombe State, suffered severe gastroenteritis after eating bean cake contaminated by pesticides. In 2008, in Bekwara Cross River State, 112 people were hospitalized and two children died due to ingestion of moi-moi and beans. The moi-moi and beans were said to have contained a large dose of highly toxic pesticides (Iyadi, 2015). The laboratory report from the National Agency for Food and Drug Administration and Control (NAFDAC) revealed that the beans were contaminated with very high concentrations of organophosphates, carbamates, fenithrothion, and chloropyrifos, all of which are highly toxic pesticides. In a different report, over 120 students of Government Girls Secondary School, Doma, Gombe State were hospitalized after consuming beans (Iyadi 2015). Samples of the meal analyzed by NAFDAC showed that the meal contained very high levels of lindane (an organochlorinated pesticide commonly called Gammallin), which may have been used to preserve the beans from ants and pest attacks. These high-profile food safety issues indicate that the unhygienic and unsafe handling and treatment of food has seriously impacted public health in Nigeria by causing numerous chronic and non-chronic diseases. Shockingly, the root causes in most of the food safety issues highlighted above were never identified, deeply investigated, and/or communicated to the public in a detailed manner. This highlights the regulatory failures to combat the current food safety problems persisting in Nigeria.

Methodology

Systematic literature review was applied to analyze sample of papers published about food supply chain, issues, food safety along value chain and food security as it's related to informal food sector. The systematic literature review was considered suitable when the principal purpose of the study was to analyse the studies on a given topic. It allows for reduction of many pieces of literature in an explicit and systematic way, providing a short coherent report that helps readers to know and understand something about a given topic (Pittaway *et. al.,* 2004; Auler *et. al*., 2016). The method helps the researcher minimise research bias and thus make research choices more explicit. The systematic review methods outlined by Tranfield *et al.,* (2003) was adopted in the selection and determination of relevant literatures as well as information collection categories.

Discussion

The food value chain

The food value chain is the network of stakeholders involved in growing, processing,

and selling and consumption of food (from farm or sea to table) This includes; the producers of food, processors, both primary and value added, distributors, including wholesalers and retailers, consumers as well as governments, and regulators that monitor and regulate the entire food value chain (Wang, 2010). Collaboration among the various stakeholders along the food value chain is more important than ever (Table 1). The interdependencies between stakeholders are no longer mainly between the functions most closely linked along the chain but can encompass stakeholders anywhere in the network. Due to the diversities of food supply chain and a number of increasing numbers of food recalls, food safety and traceability have become a major concern (Liu *et al*., 2012). Every stakeholder must be responsible and accountable for the sourcing, handling, and quality control of food because a food-related illness due to a mishap anywhere along the value chain can ruin a company's reputation, even if it is not specifically at fault. Therefore, food safety policies and regulations require the input and collaboration of all stakeholders. Knowledge and data sharing (e.g., food storage best practices, consumer trends, and inventory levels) are other areas where collaboration among stakeholders can improve efficiency along the value chain (Wang, 2010). In addition, greater vertical integration within the value chain (e.g., retailer private label programmes) means that individual stakeholders are taking on additional roles and responsibilities.

Table 1: Stakeholders in the food value chain and responsibilities

Stakeholders	**Roles**	**Key issues**
Producers	•Research and development • Farming • Ranching • Trading • Harvesting • Butchering	• Management capabilities (e.g.,brand and risk management, skill gaps) • Market strategy • Financial issues (e.g., input and sale price volatility • Strategy (e.g., going global, regulatory
Processors	• Processing • Value add processing • Manufacturing • Marketing and sales	• Supply chain strategy (e.g., vertical integration, security,safety)
Distributors	• Distributing • Retailing	• Strategy (e.g., consumer) • Supply chain strategy (e.g., vertical integration, traceability)
Consumers	• Shopping • Consuming	• Food prices (e.g., high prices, price volatility) • Food security (e.g., availability) • Food safety (e.g., traceability) • Health and wellness (e.g.,obesity)
Government/NGO/Regulators	• Public health and safety • Public policy	• Food and product safety • Security (e.g., resource, land and food availability and allocation) • Policy and support

Adapted from the Deloitte (2013)

Framework for Food Value Chain Approach to Food Safety

FAO defines the food value chain approach as recognition that the responsibility for the supply of food that is safe, healthy and nutritious is shared along the entire food chain - by all involved with the production, processing, trade and consumption of food. This approach encompasses the whole food chain from primary production to final consumption. Stakeholders include farmers, fishermen, slaughterhouse operators, food processors, transport operators, distributors (wholesale and retail) and consumers, as well as governments obliged to protect public health. (FAO, 2003) The holistic approach to food safety along the food chain differs from previous models in which responsibility for safe food tended to concentrate on the food processing sector. Its implementation requires both an enabling policy and regulatory environment at national and international level with clearly defined rules, and the establishment of food control systems and programmes at national and local levels throughout the food chain. Adopting a food chain framework goes beyond ensuring the safety of food. It facilitates more generally a consumer-driven approach to agriculture and food safety systems, implying potential future shifts in the agricultural sectors in many countries. For example, production systems may be challenged by opportunities to integrate nutritional considerations in food at source. Farmers may also need to make new farming and technology choices to meet demands for a safe and healthy diet in response to new regulations and standards, changing global consumption patterns, improved market access and value-added opportunities, as well as respond to increasing concerns over the sustainability of existing agricultural systems (Yong *et al*., 2012). According to FAO (2003), such, a framework for the future development of a food chain approach to food safety should be broadly based on three key elements:

• Universally adopting a risk-based approach to food safety.

• Complementing the current, traditional emphasis on regulation and control of end products in food safety systems with a more pronounced and comparable emphasis on prevention of food contamination at source - including development and dissemination of good practices/safety assurance systems (Hazard Analysis and Critical Control Point/HACCP).

• Adopting a holistic approach to food safety that encompasses the whole food chain which is from end to end (farm or sea to plate) and adheres to the FAO definition of a food chain approach in which responsibility for the production of safe food is shared along the entire food chain (Manzini R. and Accorsi, 2013).

Implementation of Food safety regulations along food value chain

A system of adopting a holistic, food chain approach to food safety recognizes that primary responsibility for supplying safe and palatable food lies with all those involved in food production, post-harvest treatment, processing and trade (FAO/WHO, 2003). The strategy places responsibility on all stakeholders throughout the food chain. Stakeholders may include farmers and the suppliers of farm inputs (especially animal feed and veterinary supplies), fisher folk, slaughterhouse and packing-house operators, fish processing plants, food manufacturers, transport operators, wholesale and retail traders, caterers, food service establishment operators, street food vendors and others. This responsibility also extends to the end consumer who must be educated to ensure that food is properly stored, hygienically prepared and food shelf lives are respected. A holistic, integrated food chain approach should

further engender the need for close contact and collaboration between, for example, food control authorities and those responsible for environmental protection and water quality. A revised food safety strategy incorporating a food chain approach would broaden the traditional focus on Hazard Analysis and Critical Control Points (HACCP) to include relevant components of Good Agricultural Practices (GAP) and Good Manufacturing Practices (GMP) particularly related to food safety and the food chain – *the farm or sea to plate* approach. (FAO 2005). A revised strategy would involve additional work for prevention at source, such as the development and dissemination of practices to prevent food-borne hazards (HACCP) from entering the food chain. Improving Food Safety along the value chain can also be achieved through the following efforts as outlined by (FMARD 2017)

a. *Promoting good agricultural practices (GAP) among farmers*: This will ensure that the exposure of foods to biological and chemical hazards is reduced. GAPs include the use of improved seeds, appropriate use of inputs (fertilizers, pesticides, etc.), use of biological controls (e.g., Aflasafe), integrated pests management, and moisture regulation (Table 2:).

Table 2: **Cases of Microbial Contamination along food value chain and possible interventions using a food Safety Management System**

Microbial contamination	Stages/causes	Interventions needed
Contamination of raw materials	• Fresh vegetable products implicated as sources of infection • Inappropriate suppliers' processes or wrong storage may cause microbial contamination	○ Apply good agricultural systems and more hygienic performance • in both crops and on farms ○ Establish effective cleaning/sanitizing programmes • • Avoid cross contamination of a suspected food product or animal
Risk in food packaging	• Air combined with packaging in the food supply chain is one of the major potential sources of pathogenic microorganisms	• Use appropriate air filters combined with production processes can control microbes • Use good hygienic practices in food processing and supply.
Risk in food refrigeration	• Inappropriate refrigeration systems can cause microbial contamination	• Refrigerate food products to prevent the growth of spoilage and pathogenic microorganisms.
Risk in transportation and food service operations	• Unsuitable transportation services can cause microbial contamination • Product handling at the end destination and/or at wrong temperatures can cause microbial contamination	• Employ time and temperature control in all stages of transportation • Use good personal hygiene • Establish effective cleaning/sanitizing programmes

Adapted from Elkhishin et al., (2017)

b. *Scaling up the use of modern drying and storage techniques and technologies*: Such techniques include precision drying of produce and hermetic storage which control for temperature, moisture, and insect attack.

c. *Irradiation of food products*: The entry point will use gamma irradiation for food preservation, especially fruits, vegetables, and meat/meat products

d. *Compliance with Aflatoxin Control Initiative*: The entry point will minimize aflatoxin contamination along the value chain. Necessary actions will be supported at pre-harvest, *harvest, in storage, during processing, in markets, and at consumer level.*

e. *Ensuring that agricultural practices and produce conform to Codex standards along the value*
Chain: This entry point will ensure that relevant regulators provide inputs into the setting of Codex standards, including standards for pesticide residues, metallic contaminants, among others.

f. *Collaborating with food safety regulatory agencies to facilitate compliance with standards*: The entry point will ensure that export-oriented farmers are aware of international food standards and are able to meet these standards. To facilitate this action, a certification system will be developed with these agencies to endorse foods meeting specific standards.

g. *Ensuring greater support for actions that promote food safety*: The use of adequately equipped
and functional storage technologies and techniques such as silos, warehouse receipt systems, and
Commodities exchange boards will be promoted.

Improving food safety knowledge and practices in informal sector

The review of the food safety policy and existing laws and regulations showed that despite the socioeconomic importance of street food vending, the present regulatory framework did not make provisions for adequate regulation of the informal sector that serves many Nigerian consumers, a finding consistent with previous studies (Eziringwe, 2018; Ukwueze, 2019). According to a recent study, the activities of the State Ministries and Local Government Authorities in the control of the safety and quality of unprocessed food should be streamlined. It found that food hazards happen more at the local or grass root level and recommended stringent measures should be enforced to curb them by empowering the Local Authorities to prosecute offenders, which would compel manufacturers, sellers, retailers and consumers to adhere to standards (Ukwueze, 2019; Nwamkemba *et al*., 2012). Creating greater and inclusive food safety sensitization and awareness programs and activities among operators of the informal street food sector to enable them to understand basic principles and significance of food safety and the need to adopt good personal hygiene practices is critical. During the consultation with different stakeholders, they expressed concerns about the lack of awareness on existing food safety regulations by the informal market providers, and described ignorance, negligence, and neglect by the street food handlers as well as inadequate oversight by the regulators. Development and implementation of relevant programs to educate street vendors and consumers on food safety and hygiene requirements will support safe street food vending practices in Nigeria

According to the Federal Ministry of Health (FMOH) (2014), the Local Government Area Councils are vested with the mandate for regulating food safety of street vended foods, bukaterias, catering establishments, local abattoirs and traditional markets. Food hazards,

including foodborne disease outbreaks happen at the local or grass root community level, where the population has limited knowledge of food safety and its public health implications. Thus, regulatory agencies and other relevant stakeholders should accord priority to developing public awareness on food safety and its importance to public health, especially for food business operators in the informal sector. Stringent measures should be adopted and enforced to reduce food hazards in this sector and local authorities should prosecute offenders. This would compel food sellers, retailers and consumers to adopt good hygiene practices and adhere to standards (Ezringwe, 2018). In the absence of strict standards, consumers cannot take advantage of the redress mechanism put in place to help them when their rights are infringed upon (Ukwueze, 2019).

Based on the outcome of the consultations with food safety stakeholders on their opinions about ensuring food safety in informal markets, the following areas for needed improvement:

• Provide training on food safety and hygiene for Local Government Area Council Staff responsible for food safety regulation in informal markets.

• Provide public engagement on food hygiene, safety, and nutritional quality to actors and stakeholders in informal market settings to enhance the safety and quality of food and food products purchased and consumed by consumers.

• Support training on good agricultural practices (GAP) to famers and Good Hygienic Practices (GHP) to food handlers, vendors and consumers.

• Develop and maintain effective and symbiotic relationships with umbrella associations for effective dissemination of information and/or delivery of training programs on food safety and hygiene to: improves personal hygiene of food vendors and the hygiene of sales equipment and sites by providing clean water points and toilets.

• Improve on regularity and effectiveness of removal of waste materials from markets and points of sale.

Challenges in the implementation of food value chain approach to food safety in Nigerian informal food sector

Food supply chain is characterized with its complexity, which is one of the most important reasons for what makes the matter of food safety complicated. There is a great deal of links in food supply chain, interconnected with each other, and as long as one of them is out of work, the problems of food safety will be aroused, even putting threats to human welfare. Therefore, food supply chain safety is critical to guarantee safe and efficient food supply. The linked nature of food safety control throughout the supply chain creates challenges for the design of regulation. When designing standards, regulators may focus on either outcomes (contamination in foods), or processes (adherence to specified protocols). This encourages variability in the supply chain behavior and risk modeling when integrated in order to better identify the most cost-effective interventions and policy actions (Hoffmann 2010). Issues around food preparation, safety, sale, and the consumption of street foods in inappropriate places are on the rise in Nigeria, making it exceptionally challenging to promote food safety culture in Nigeria. Furthermore, an inefficient food supply chain, poor traceability, and a lack of understanding of food safety and quality standards have contributed to these challenges (Onyeaka *et al*., 2021). The lack of data on the incidence of foodborne disease outbreaks in Nigeria and lack of awareness of the socioeconomic consequences of food safety issues have not helped either. Other key obstacles to food safety in Nigeria include the lack of a positive attitude towards risk management and an unwillingness to learn from

accidents, near misses, and safety performance indicators. Unsafe elements of food supply exist in various places in food supply chain. They can be found in supplying link, in processing link, in transporting link, or in consuming link and the like (Onyeaka, *et al*., 2021. These ubiquitous underlying problems usually owe to human behaviors. Human beings are indispensible in food supply chain, for the food supply chain is run only by different kinds of human activities. However, due to the limitation of perception, human do not always behave right, which leads to difference between behaviors and expectations, and generates food safety problems (Liu *et al*., 2012). Every participant in food supply chain behaves variously, even one person behaves differently in different period of time. This diversity of human behavior adds uncertainty to supply chain. Thus, human behavior is one of the critical factors that determine the food supply chain safety risk, and preventing and controlling food supply chain safety risk from a behavioural perspective is becoming a practical problem that is urgent to be solved (Yang *et al*., 2012). Training Centers, Laboratories, Research Institutes and Suppliers of packaging and chemicals are often not established in the grower's areas. Those that do exist frequently provide unsatisfactory service. The fact that they operate in some urban areas with lack of basic facilities makes it more difficult to access services and support technology. New technology is not a prerequisite for HACCP but it simplifies the implementation vastly (Nicolaides 2002). Inadequate technical resources is more often observed in small food industries, as few of them have personnel who understand the technology involved in the process they utilize. This results in inadequate attention given to the control of quality. There are challenges of control over the quality of raw material purchases some firms, particularly small processors, have little control over the quality of raw material purchases including purchases of packaging materials. Small firms have limited control because they have limited operating capital and purchase much lower volumes of these materials. Lack of proper training of employees on quality programmes hinders appropriate quality programmes from being delivered to these segments of the workforce to suit their level and ensure that the owners (traditional) and their educated and uneducated workforce work on the activities that are most important for the success of the business by accomplishing work group missions in efficient ways and eliminate work that is wasteful. There are financial challenges such as high costs for modification of process and work systems in adoption of principle and rules of GPs and HACCP in majority of small and medium food processing enterprises.

Suggested policy and regulatory approach to promote the implementation of Value chain approach to food safety in informal food sector

1) An active government intervention to promote and facilitate adoption of Good Practices and HACCP by raising the awareness on the following;

- Benefits and the need for introducing Good Practices and HACCP to produce safe food.
- Benefits achieved in implementing a food safety management program.
- Risks inherent in certain food stuffs or production processes.
- Cost resulting from production failure.
- Value of HACCP in safeguarding the enterprise image from any associated outbreaks or product recall.

2) A strong government commitment in the development and implementation of a successful food safety initiative through the conduct of the following activities;

- Identification of the industry sectors for which food safety measures implementation is more important.

• Establishment of a food safety Implementation Committee involving all interested parties, i.e., concerned government agency, food industry, private consultants, regulators.
• Conduct a media campaign.
•Development of HACCP guidance materials and HACCP generic models for priority products
• Training of regulatory personnel on HACCP.
• Ensure through regulatory authorities that GMP is in place.
• Funding support to accelerate the implementation of HACCP in high risk sectors.
• Development of schemes that recognize HACCP systems such as accreditation programs.

3) Review of food laws to shift from end-point testing to a safety management system approach. When appropriate, the government may need to consider the necessity of mandatory measures.

4) Encouragement of the processors to practice GMPs to cope with the difficulties associated with implementing HACCP. This will serve as an initial step to follow a graduated or stepwise approach to HACCP implementation.

5) The government should encourage regulators, industry, educational institutes and independent experts to accept their roles in assisting small-and medium-sized food processors in applying HACCP-based quality assurance systems.

6) Technical support from the government for the following:
• The availability of appropriate current scientific support.
• Access to low-cost analytical services.
• Establishing and maintaining food-borne disease surveillance programs and access to collected epidemiological data.

7) Strengthening the market requirement for quality assessment through better implementation of food regulations on food safety and quality.

8) Continuous monitoring and assessment by the government of the effective application of Good Practices and HACCP and the prerequisite practice by food establishments.

Conclusions

Food safety is a complex issue that remains a challenge even for high income countries. Increasing public awareness of food safety hazards, concern over threats to health attributable to food hazards and reduced confidence in the ability of current food supply systems to manage food safety risks are additional factors that were considered in the development of a food chain strategy. Food safety has traditionally focused on enforcement mechanisms to remove unsafe food from the market, instead of a more pronounced mandate for the prevention of food safety problems. Generally, the orientation of many food safety systems tends to be reactive and defined by enforcement criteria instead of preventive and holistic in the approach to risk assessment and reduction. Integrated strategies for reducing the most significant risks throughout the entire food chain is incorporated into the revised strategic direction in food safety systems. Adopting a food chain framework goes beyond ensuring the safety of food. It facilitates more coordinated approach to agriculture and food safety systems, implying potential future shifts in the agro-food sectors. A revised strategic direction that incorporates a food chain approach would assist stakeholders to establish or improve comprehensive food safety systems, from primary producer to consumer – *from farm or sea to the plate* - as the food chain approach as described. The food chain approach uses a scientific, systematic approach known as the Hazard Analysis and Critical Control Points (HACCP) to identify, assess and control hazards during production, processing, manufacturing and preparation of food. For HACCP to be effective, a strong foundation of safety related prerequisites is essential. Prerequisite

programmes include, among others, the implementation of good manufacturing practices, good agricultural practices and good hygiene practices.

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Agro-Morphological Characterization And Yield Of Newly Cip Introduced And Adapted Sweetpotato Varieties In Uyo, Nigeria

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Abstract: *Field studies were conducted in 2021 cropping season at the National Cereals Research Institute, Uyo Outstation and farmers plot in Owot-Uta, Akwa Ibom State, Nigeria to evaluate the morphological characters and yield of 25 sweet potato genotypes comprising 13 Nigerian released and 12 newly introduced CIP varieties. Each experiment occupied a land area 75 m x 11 m and was laid out in a randomized complete block design with three replications. The study evaluated 11 qualitative characters and 10 quantitative characters. The results showed significant differences ($p<0.05$) among the sweet potato genotypes in all the quantitative characters. Four sweet potato genotypes showed superiority in storage root yields and quality tuber characteristics. These could be incorporated into breeding programme to produce hybrid varieties namely 87/OP/195 (48.9 tha^{-1}), PGA 14442-1 (41.6 tha^{-1}), PGA 14011-43 (31.9 tha^{-1}) and Butter milk (30.9 tha^{-1}), while 87/OP/195 could be recommended for cultivation in Uyo why only Uyo, what about other local government? southeastern Nigeria. For proper weed control and high fodder yields, Nwoyorima and PG 14008-9, with 2.9 kg/plant and 1.5 kg/plant top biomass are suitable candidates, while 87/OP/195 can be considered as dual-purpose sweet potato in consideration of yield (48.9 tha^{-1}) and high-top biomass (1.2 kg/plant).*

Keywords: Characterization, growth characters, yield components, top growth, sweet potato.

CITATION:
Bassey, E. E., Harry, G. I., Peter, A. M. and Akpan, M. P. (2023). Agro-Morphological Characterization and Yield of Newly Cip Introduced and Adapted Sweetpotato Varieties in Uyo, Nigeria. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 422-436

Introduction

Sweet potato (2n=6x=90) is a widely grown important staple crop in most parts of tropical and subtropical regions of the world (ICAR, 2007), being cultivated in more than 100 countries (Woolfe, 1992; Bassey, 2021). Though perennial, it is cultivated as an annual crop of short duration and belongs to the bindweed or morning glory family *Convolvulaceae* (Tortoe, 2010; Bassey *et al*., 2022). Sweet potato (*Ipomoea batatas*) is not closely related to the common potato (*Solanum tuberosum*) and entirely unrelated to the true yam (*Dioscorea* spp) (Bassey, 2021). It produces large sweet tasting, starchy tuberous roots rich in minerals and vitamins (Tortoe, 2010) within four months (Bassey *et al.*, 2022) with 30 to 50 percent higher starch content compared with rice, corn and wheat grown under similar environmental conditions (Harry and Ulasi, 2022). Sweet potato

ranks second in importance after cassava among root crops (Ray and Ravi, 2005), seventh most important among the world food crops after wheat, rice, maize, potato, barley and cassava (Gundadhur, 2012; Sugri *et al*., 2017), third in value of production and fifth in caloric contribution to human diet (Bouwkamp, 1985; Antiaobong and Bassey, 2009). Its high photosynthetic efficiency of the leaves, high yielding potential per unit area per time (Nedunchezhiyan *et al*., 2014), hardiness and ability to grow on marginal soils (Sugri *et al*., 2017), early maturity of 3 – 4 months (Antiaobong and Bassey, 2009) and long shelf life almost similar to yam and availability all year round (Bassey, 2021) among others make sweet potato an ideal food crop for rural poor farmers. Wide variability exists in sweet potato, both in morphological characters and yield (Bassey *et al*., 2022). Sweet potato varies in growth habits (spreading, extremely spreading, erect and semi-erect), skin colour (white, light purple, purple, pink) and flesh colour (white, cream, yellow, pink, light purple, purple and red) (Nwankwo *et al*., 2014; Nwankwo *et al*., 2021). The leaf shape varies from entire to deeply lobed, while tuber root shape varies from round, ovate, obovate, round elliptic, long, large-long, long elliptic, long irregular and curved (Nwankwo *et al*., 2021).

Similarly, variability in yield components have been reported especially in number of tubers per vine, length of tubers, circumference of tubers, fresh weight of tubers, and fresh tuber yield, which constitute variable and complex characters in sweet potato (Bassey *et al*., 2022). Significant progress has been made in the breeding and selected of sweet potato for high root yields through introgression. Selection for high root tuber yields, along with high tuber quality, such as excellent root shape and form now constitutes an important aspects of sweet potato improvement (Nwankwo *et al*., 2021). Selection has also extended to high starch content for food and industrial purposes (Nwankwo and Bassey, 2013). There is also a paradigm shift from root yield to dual-purpose sweet potato genotypes to meet the needs of mixed crop – livestock farming system prevalent in developing countries (Shumbusha *et al*., 2019; Urgessa *et al*., 2014).

The major constraints to sweet potato production are low yields per unit area, especially from marginal soils, unavailability of high yielding seed vines during the growing periods and pests and diseases (Nwankwo *et al*., 2021). Yields vary according to cultivars, cropping environments and cultural techniques (Antiaobong *et al.*, 2009). Generally, yields in farmers' plots are low due to the use of local genotypes with genetic loss (Njoku *et al*., 2009; Nwankwo *et al*., 2014). Resources for evaluation of a large number of genotypes at a time are limited (Bassey *et al*., 2022), for the purpose of identifying superior genotypes with desirable yield characteristics. A clarion call for evaluation stems from the fact that estimated yields as low as 2.6 tha^{-1} to 4 tha^{-1} have been reported in Nigeria, compared with average in Africa (9.6 tha^{-1}), China (22.0 tha^{-1}) and the world (15.9 tha^{-1}) (Tewe *et al*., 2001). Such evaluation must relate with the standard check or recommended variety (carotene and non-carotene) of sweet potato available for cultivation in a given area. Therefore, the objective of this study was to assess the variability in agro-morphological characters and yield of Nigerian released and newly introduced CIP and Nigerian sweetpotato genotypes in Uyo, Nigeria.

Materials and Methods

Field experiments were conducted at the National Cereals Research Institute, Uyo Out-station, Owot-Uta, Akwa Ibom State, Nigeria. It lies within latitude 05°16' and 05°27' north and longitude 07°27' and 07°56' east of the Greenwich Meridian and altitude 45 m above sea level (Bassey *et al*., 2022). The area is a fairly

flat terrain which receives average rainfall of over 2,500 mm with daily photoperiod of 3.5 h. The temperature is generally high ranging from 23°C to 34°C throughout the year. Mean relative humidity is about 78% with the lowest (70.4%) and highest (86.6%) values in December/January and July, respectively (Umoh, 2013). The study sites were allowed to fallowed for two years before being used for the experiment.

Twenty-four (24) sweet potato genotypes (comprising 12 newly introduced CIP and 12 Nigerian released) were obtained from the National Root Crops Research Institute (NRCRI), Umudike, Abia State, Nigeria, namely: PGA 14008-9, Obare, Kwara, NAN, CRI-Apomuden, PG 17362-N1, 87/OP/195, PGN 16021-39, CEMSA 74-228, TIS 87/0087 (check), PGA 14442-1, Butter milk, PGA 14011-43, PGA 14398-4, CRI-Dadanyuie, PGA 14372-3, CRI-Okumkom, PO3/35, PGA 14351-4, UMUSPO/3 (check), Tu-Purple, Nwoyorima and PO 3/116, with Uyo Local Best (Adaptive cultivar obtained from farmers in the area).

A land area of 75 m x 11 m in each of the locations was mechanically ploughed and ridged 1 m apart and laid out in a randomized complete block design and replicated three times. The replicates were separated by 1 m paths. The ridges measured 3 m x 1 m. Each plot consisted of three ridges, which resulted in 75 plots in each of the experimental farm. Healthy sweet potato vine cuttings, each measuring 30 cm long, with at least 6 nodes were planted on crest of the ridges at 30 cm intra-row and 100 cm inter-row. The sweet potato vines were planted solely. All the 25 sweet potato genotypes were assigned to the plots randomly. Thirty (30) healthy sweet potato vine cuttings were planted per plot, giving 2,250 vine cuttings for each of the experimental farm, equivalent to 30,000 plants per hectare (Bassey *et al*., 2022). Weeding was manually done two times to prevent competition of weeds with the crops. Fertilizer NPK (15:15:15) was applied at 400 $kgha^{-1}$ to improve the nutrient status of the soil. Four plants were randomly selected and tagged at the centre of each plot for data collection. The qualitative characters investigated were: Leaf shape, colour of young and mature leaves, petiole colour, vine colour, tuber skin and tuber flesh colours, root size, form and shape and ground cover/plant habit. Quantitative characters investigated were vine length (cm), numbers of leaves, leaf area (cm^2), number of branches/vine, top biomass (kg/plant), length of root tubers (cm), circumference of root tubers (cm), number of root tubers per plot, stands at harvest/plot and storage root yield (tha^{-1}). All the data were collected at 16 Weeks After Planting (WAP).

Vines with young and old leaves of the 25 sweet potato genotypes were cut on plot basis between 7.30 – 8.00 am and carefully placed in separate labelled polythene bags and taken to the Agronomy Laboratory of the University of Uyo for the determination of colours of young and old leaf colours and vine and petiole colours. The vines with petioles and leaves were first rinsed in clean water and spread on laminar table for 30 minutes to dry off-surface water before being compared with the Munsen colour charts. Similarly, samples of storage roots of tagged plants were harvested without bruises and put into separate labelled polythene bags and taken to the laboratory, where they were carefully washed with clean running water to expose the skin surface (colour) and also kept for 30 minutes to dry off surface water before being cut into two halves to expose the flesh colour. Colours of skin and flesh colours were determined by matching with the colours on the Munsen chart. The standard skin colours were, 1 = white, 2 = cream, 3 = yellow, 4 = orange, 5 = brownish orange, 6 = pink, 7 = red, 8 = purple-red and 9 = dark purple. Similarly, the standard flesh colours were: 1 = white, 2 = cream, 3 = dark cream, 4 = pale yellow, 5 = dark yellow, 6 = pale

orange, 7 = intermediate orange, 8 = dark orange and 9 = purple (Nwankwo *et al*., 2021). Also, the descriptor for plant habit and ground cover for the sweet potato genotypes were determined using the scale 1 – 5, where 1 = 1 - 25% ground cover; 2 = 26 – 49% (<50%) ground cover, 3 = 50 – 75% ground cover, 4 = 76 – 90% ground cover and 5 = 91 – 100% ground cover (i.e. >90%) (Nwankwo *et al*., 2021). Root size and root form were investigated based on inspection of harvested root tubers and categorized, as 1 = Excellent, 2 = very good, 3 = good, 4 = fairly good, 5 = Fair, 6 = Poor, 7 = Very poor, 8 = extremely poor and 9 = terrible. Shapes of the sweet potato tubers were compared with the standard tuber shapes (figures) (CIP, 2020) and categorized accordingly. Leaf shapes were also compared with the standard leaf shapes (CIP, 2020).

All the quantitative data were subjected to Analysis of variance and the means separated with Duncan Multiple Range Test at 5% probability level, following the procedure by Wahua (1999).

Results

The results (Table 1) show variability in qualitative characteristics of the 25 sweet potato genotypes, representing both Nigerian released and newly introduced CIP clones in terms of leaf shape, colour of young and mature leaves, petiole and vine colours, tuber skin and flesh colours, root size, form and shape and growth habit and ground cover. The triangular leaf shape was predominant among the local and newly introduced genotypes and found in PGA 14008-9, Obare, NAN, PG 17362-NI, 87/OP/195, PGA 14011, PGA 14398-4, CRI-Dadanyuie and Uyo Local Best constituting 36% of the total entries, followed by seven genotypes with lobed leaves, namely PGN 16021-39, CEMSA 74-228, PO3/35, PGA14351-4, PG-17265-NI, Nwoyorima and P03/116, constituting 38% of the total entries. The result also identified five sweet potato genotypes with hastate leaves namely Kwara, PGA 14372-3, CRI-Okumkom, UMUSPO/3 and TU-Purple contributing 20%, while four (4) genotypes were cordate, namely CRI-Apomuden, TIS 87/0087, PGA 14442-1 and Butter Milk, giving only 16%. In this study, sweet potato genotypes with young purple leaves either partly, veined or completely purple tinged (pigmented) constituted the predominant colour, except CEMSA 74-228, CRI-Dadanyuie, PGA 14351-4, and UNUS PO/3 which produced young green leaves, constituting 84% and 16% respectively. Colour of mature leaves varied among the sweet potato genotypes and ranged from light green, dark green, green with purple pigmentation on leaf margin and completely purple. However, the predominant mature leaf colour was green, whether light, dark green or green tinged purple, found in 23 sweet potato genotypes, constituting 92% of the entries, while only 2 genotypes produced mature purple leaves, namely TU-purple, and PG 17265-NI.

Variations in petiole colour were observed in the 25 sweet potato genotypes. The predominant petiole colours were light green, dark green or green with purple pigmentation either concentrating at the base of the leaf and decreasing downward or decreasing from the base of the petiole to the leaf base, all accounting for 68% of the total entries. Five genotypes produced purple petioles namely Obare, Kwara, CRI-Apomuden, PGA 14351-4 and UMUSPO/3, while 3 produced pink petioles, namely PG 17362-NI, PGN16021-39 and CEMSA 74-228, contributing 20% and 12% respectively. Similarly, 20 sweet potato genotypes produced vines which were light green, green and dark green with brown or purple pigmentation, while 5 were completely purplish, namely PGA 14372-3, PGA 143351-4, UMUSPO/3, TU-Purple and PO3/116, accounting for 80% and 20%, respectively.

Large variability in tuber skin colour was observed among the 25 sweet potato genotypes

involved in the study. Pink skin colour of different shades were observed with 13 genotypes, namely: PGA 14002-9, Obare, NAN, PG 17362-NI, 87/OP/195, CEMSA 74-228, TIS 87/0087, PGA 14442-1, PGA 14398-4, CRI-Dadanyuie, CRI-Okumkom, PO3/35, PG17265-NI, accounting for 52% of the total entries, followed by 5 genotypes with orange pigmentation, namely Kwara, CRI-Apomuden, PGA 14011-43, PGA 14351-4, and UMUSPO/3, while 3 produced yellow tuber skin namely PGA14372-3, TU-Purple, and PO3/116 accounting for 20% and 12%, respectively. Only Butter milk produced cream tuber skin. Similarly, large variability was observed in tuber flesh colour, from cream, yellow, orange, pink to dark purple. The predominant flesh colour was orange, found in 12 genotypes, namely Obare, Kwara, NAN, CRI-Apomuden, 87/OP/195, CEMSA 74-228, CRI-Okumkom, PGA 14351-4, Nwoyorima, UMUSPO/3, PG 17265-NI and PO3/116 contributing 48%. Cream flesh tubers were found in eight sweet potato genotypes, namely PGA 14008-9, PG 17362-NI, TIS 87/0087 (check), PGA 14398-4, CRI-Dadanyuie, Uyo Local Best, PGA 14372-3 and PO3/35, contributing 32%, while three sweet potato genotypes produced yellow flesh tubers, namely PGN 16021-39, PGN 14442-1 and Butter milk, contributing 12%. Purple-fleshed tubers were produced by TU-Purple, while PGA 14011-43 produced pink fleshed tubers, contributing 4% each (Table 1).

Root size, form and shape showed large variability among the 25 sweet potato genotypes in the environment (Table 1). Three sweet potato genotypes produced excellent root size and forms, namely 87/OP/195, PGA 14442-1 and Butter milk, and were accordingly rated 1st while root size and forms of three genotypes were very good, namely PGA 14011-43 and UMUS PO/3 and NAN which were scored very good also had excellent root form. Three sweet potato genotypes produced good root size and form, namely PG 17362-NI, PGA 14372-3 and PG 17265-NI and were accordingly rated third. Also, ten sweet potato genotypes produced root size and form that were fair and accordingly scored 5th, namely PGA 14008-9, Kwara, CRI-Apomuden, CEMSA 74-228, TIS 87/0087 (check), CRI-Dadanyuie, Uyo Local Best, CRI-Okumkom, TU-Purple and PO3/116, while six genotypes were rated very poor (7th), namely Obare, PGN 16021-39, PGA 14398-4, PO3/35, PGA 14351-4 and Nwoyorima. Similarly, root shape of the 25 sweet potatoes varied largely from round, ovate, obovate, round elliptic, long, large-long, long elliptic, long irregular to curved (Table 1). Two sweet potato genotypes produced round storage roots, namely TU-Purple and PGA 14372-3, four ovate, namely Kwara, PGA 17362-NI, PO3/35 and Nwoyorima, while NAN was obovate. Similarly, Uyo Local Best and UMUSPO/3 were round elliptic, while Butter milk was long. Seven sweet potato genotypes produced root tubers which were long elliptic, namely Obare, CRI-Apomuden, PGA 14442-1, PGA 14011-43, PGA 14398-4, CRI-Dadanyuie and PG 17265-NI while five sweet potato genotypes produced long irregular root tubers, namely, PGA 14008-9, 87/OP/195, CEMSA 74-228, TIS 87/0087, and PO3/116. Large long storage roots were produced by PGN 16021-39 (Table 1).

The growth habit of the 25 sweet potato genotypes also varied, ranging from semi-erect, to extremely spreading types. Three sweet potato genotypes were classified semi-erect, namely CRI-Dadanyuie, CRI-Okumkom and PO3/35; thirteen were spreading types namely Obare, Kwara, NAN, PG 17362-NI, 87/OP/195, PGN 16021-39, CEMSA 74-228, TIS 87/0087, PGA 14442-1, Butter milk, PGA 14372-3, PGA 14351-4, TU-purple and PO3/116. Similarly, eight (8) sweet potato genotypes were extremely spreading types, namely PGA 14008-9, CRI-Apomuden, PGA 14011-43, PGA 14398-4,

Uyo Local Best, UMUSPO/3, PG 17265-1 and Nwoyorima (Table 1).

Growth characters and yield components of the 25 sweet potatoes were significantly different ($p<0.05$) (Table 2). The longest vines were produced by PGA 14398-4 (640.4 cm), followed by CRI-Okumkom (511.6 cm), Nwoyorima (450.0 cm), while the shortest vines were NAN (47.6 cm), PO3/35 (56.4 cm) and PG 17362-NI (70.6 cm). The result identified PO3/116 (305.6) with the highest number of leaves, followed by Nwoyorima (with 230.2) and CRI-Okumkom (204.2), while the lowest were observed in PO3/35 (16.6) followed by CEMSA 74-228 (18.6) and Butter milk (21.5). Leaf area differed significantly ($p<0.05$) among the 25 sweet potato genotypes with the largest produced by UMUSPO/3 (63.04 cm^2), followed by PGA 14372-3 (54.80 cm^2) and PG 17265-NI (50.76 cm^2), while the smallest leaf area came from PO3/35 (0.62 cm^2) and CRI-Apomuden (0.7 cm^2). Number of branches varied significantly ($p<0.05$) among the genotypes, the highest being produced by PGA 14442-1 (10.4), 87/OP/195 (10.2) and Butter milk (8.8) while the lowest were PO3/35 (0.8), TU-Purple (2.6), and CRI-Okumkom (3.2).

The highest top growth (kg/plant) were produced by Nwoyorima (2.9 kg), PGA 14008-9 (1.5 kg), and PGA 14442-1 (1.4 kg) while the lowest came from NAN (0.2 kg) and CEMSA 74-228 (0.2 kg), followed by five genotypes with similar value (0.3 kg), namely, CRI-Apomuden, PG17362-NI, PGN 16021-39, TIS 87/0087 (check) and PO3/35. Length of root tubers varied significantly ($p<0.05$) among the 25 sweet potato genotypes, the highest being produced by Nwoyorima (39.9 cm), followed closely by PGA 1435-4 (38.4 cm), while the shortest was CEMSA 74-228 (1.4 cm). Similarly, significant differences ($p<0.05$) were observed among the sweet potato genotypes in tuber circumference, the largest being produced by PGA 14372-3 (30.4 cm) followed by Uyo Local Best (26.6 cm) and Nwoyorima (20.4 cm), while the smallest circumference was produced by CEMSA 74-228 (1.7 cm). Storage roots per plot differed significantly ($p<0.05$) among the 25 sweet potato genotypes. The highest number of storage roots per plot was produced by PGA 14372-3 (77.2), followed by Uyo Local best (46.0) and CRI-Apomuden (33.4), while the lowest were produced by PO3/35 (2.3) and NAN (2.6). Similarly, number of stands at harvest differed significantly ($p<0.05$) among the 25 sweet potato genotypes with 87/OP/195 (12.4) producing the highest, followed by TU-purple (10.2) and PGN 16021-39 (9.4) and PG 17265-NI (9.4), while the lowest was produced by NAN (3.4). Storage root yield (tha^{-1}) differed significantly ($p<0.05$), among the sweet potato genotypes, with 87/OP/195 producing the highest fresh tuber yield (48.9 tha^{-1}), followed by PGA 14442-1 (41.6 tha^{-1}), PGA 14011-43 (31.9 tha^{-1}) and Butter milk (30.9 tha^{-1}), while the lowest tuber yield of 1.8 tha^{-1} was produced by Kwara.

Discussion

Variability in both qualitative and quantitative characters observed among the 25 sweet potato genotypes, comprising both local and newly introduced CIP clones is important and necessary for further breeding and selection of sweet potato for the environment. In a similar study, Bassey *et al.,* (2022) reported variation in skin and flesh colours and reported that carotenoids in sweet potato tubers are of great health benefits especially in poorer countries where there is no access to vitamin A supplements by the majority of people. Takahata *et al*., (1993) associated carotenoid content with anti-oxidant effect, capable of improving the health of children and lactating mothers in poorer countries. Similarly, Shumbusha *et al*., (2019) reported that high beta-carotene has been noted to be rich in anti-oxidant and can be employed as a preventive

measure against asthma, gout and arthritis in humans. UNICEF (1998) updated report? Too old reported that as many as 17.4 million people in West African and Central Africa show clinical signs of vitamin A deficiency in 19 countries, resulting in 20 – 30% mortality in children below the age of five. According to Akinwale *et al*., (2010), the average daily requirement of β-carotene recommended by the World Health Organisation (WHO) is 2.4 to 3.5 for adults. The result of this study identified 17 sweet potato genotypes with high content of B-carotene and could be recommended for consumption for the overall wellbeing of the people. Estimates of β-carotene in NASPOT UMUSPO/1, Lourdes, Erica, Delvia and UMUSPO/3 were made by Harry and Ulasi (2022) which indicated values ranging from 8.02 (intermediate), 4.19,1.03, 1.63, 4.23 mg/100g for pale yellow and 9.19 (deep orange) respectively.

Although the genotypes in this study were not analyzed for β-carotene and carotene group, the colours which ranged from orange, brownish orange, yellow, pink, purple and purple red, indicate the presence of higher β-carotene contents in the storage roots. This study, identified some morphological markers in sweet potato which may correlate significantly with some important yield components such as colours of young and mature leaves, petiole and vine and leaf shape, which calls for follow-up or further investigations. Root-size, root form and root shape in the 25 sweet potatoes are important attributes of storage roots which are needed by consumers and call for not just breeding for tuber yield but also desirable root qualities.

Sweet potato genotypes such as PGA 14398-4, Nwoyorima, UMUSPO/3 CRI-Okumkom, CRI-Dandayuie, PG 17265-NI with vine length ranging from 350 - 650.4 cm, habit and ground cover (70 – 100%) and higher number of leaves and leaf area could be adopted in mixed cropping in the humid tropics where weed infestation poses great challenge to farmers (Antiaobong and Bassey, 2008; Korioecha *et al*., 2009). Top growth together with vine length, number of leaves, leaf area and number of branches are important characters which determine the forage yield in sweet potato (Nwankwo *et al*., 2021) and directly suggests the sweet potato genotypes for selection for mixed crop/livestock system.

Variability in yield and yield components among the sweet potato genotypes in terms of length of tubers (cm), circumference of tubers (cm), number of storage roots per plots, stands at harvest and storage root yield suggest for crossing of sweet potato genotypes with superior traits in order to develop hybrid varieties for the area (Bassey *et al.,* 2022). For example, while Nwoyorima produced the longest storage roots (39.9 cm), followed by PGA 14351-NI (38.4 cm) and PGA 17265-NI (30.6 cm), which were greater than the two national checks (UMUSPO/3-17.4 cm and TIS 87/0087 (15.6 cm) and Uyo Local Best (20.6 cm), only two genotypes produced the widest tuber circumference greater than all the two national checks and local best namely 87/OP/195 (31.0 cm) and PGA 14372-3 (30.4 cm). According to Nwankwo and Bassey (2021) and Bassey *et al*., (2022), length and circumference of tubers are important yield contributing characters which must be considered in sweet potato yield improvement programme. Number of storage roots per plot and stands per plot did not translate to storage root yield (tha^{-1}). For example, 87/OP/195 produced the highest storage root yield (48.9 tha^{-1}), followed by PGA 14442-1 (41.6 tha-1), PGA 14011-43 (31.9 tha^{-1}) and Butter milk (30.9 tha^{-1}), while PGA 14372-3 produced the highest number of root tubers per plot, followed by the Local Best (46.0). Similarly, the highest stands at harvest came from 87/OP/195 (12.4) followed by TU-Purple (10.2), which were greater than those of the checks. Based on the productivity of the genotypes, the

first top yielder (87/OP/195) could be recommended for cultivation in Uyo since it out-yielded both the national checks and Uyo Local Best in the environment, while all the four top yielders should be incorporated into breeding programmes to produce hybrid varieties.

Conclusion

Four sweet potato genotypes, namely 87/OP/195 (48.9 tha^{-1}), PGA 14442-1 (41.6 tha^{-1}), PGA 14011-43 (31.9 tha^{-1}) and Butter milk (30.9 tha^{-1}), identified with superior yields than the world's average (15.9 tha^{-1}) and the two national checks UMUSPO/3 (17.3 tha^{-1}) and TIS 87/0087 (11.6 tha^{-1}) and Uyo Local Best (18.6 tha^{-1}) could be incorporated into breeding programmes to produce hybrid varieties for the area. As a short-term measure, 87/OP/195 could be recommended to farmers in Uyo, Southeastern Nigeria. In selecting sweet potato for high storage root yields, qualitative characters such as nature of leaves (shape, colour of young and old leaves), colours of tuber skin and flesh, and vine colours, should not be relied upon. Beside yield consideration, tuber quality characteristics such as size, form and shape should constitute important objective in sweet potato breeding. For weed control and fodder yield, two sweet potato genotypes with the highest top biomass, namely Nwoyorima (2.9 kg $plant^{-1}$) and PG 14008-9 (1.5 kg $plant^{-1}$) were conserved suitable candidates, while 87/OP/195 could be considered as a dual-purpose sweet potato in consideration of yield (48.9 tha^{-1}) and top biomass (1.2 kg $plant^{-1}$).

Acknowledgements

The authors acknowledge the National Root Crops Research Institute, Umudike, Nigeria for the provision of seed vines and take-off grant; Akwa Ibom State Ministry of Agriculture and Food Sufficiency, Uyo, Nigeria for land preparation and National Cereals Research Institute, Uyo Out-station, Akwa Ibom State, Nigeria for the provision of land for this research.

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Table 1: Qualitative characters of sweet potato genotypes in Uyo, Southeastern Nigeria

	Sweet potato genotypes	Plant characters										
		Leaf shape	Colour of young leaves	Colour of mature leaves	Petiole colour	Vine colour	Tuber skin colour	Tuber flesh colour	Root size	Root form	Root shape	Ground cover and growth habit
1	PGA 14008-9	Triangular	Purple	Green	Deep green	Green	Pink	Cream	5 (Fair)	5 (fair	Long irregular	Extremely spreading (ES)
2	OBARE	Triangular	Purple	Green	Purple	Green	Pink	Orange	7 (Poor)	7 (poor)	Long elliptic	Spreading (S)
3	KWARA	Hastate	Purple	Deep green	Purple	Deep green	Orange	Orange	5 (Fair)	5 (Fair)	Ovate	Spreading (S)
4	NAN	Triangular	Purple	Green with purple vein	Green	Green	Pink	Orange	2 (Very good)	1 (Excellent)	Obovate	Spreading (S)
5	Cri-Apomuden	Cordate	Green tinged purple at margin	Green	Purple	Green	Orange	Orange	5 (Fair)	5 (Fair)	Long elliptic	Extremely spreading (ES)
6	PG17362-NI	Triangular	Purple	Green	Pink	Green	Pink	Cream	3 (Good)	5 (Good)	Ovate	Spreading (S)
7	87/OP/195	Triangular	Light green tinged purple at margin	Light green	Green tinged brown at margin	Green tinged purple	Pink	Orange	1 (Excellent)	1 (Excellent)	Long irregular	Spreading (S)
8	PGN 16021-39	Lobed	Green tinged brown margin	Green	Pink	Light green	Yellow	Yellow	7 (Poor)	7 (Poor)	Large and long	Spreading (S)
9	CEMSA 74-228	Lobed	Deep green	Deep green	Pink	Green	Pink	Orange	5 (Fair)	5 (Fair)	Long Irregular	Spreading (S)
10	TIS 87/0087 (check)	Cordate	Purple	Green	Light Green	Light Green	Pink	Cream	5 (Fair)	5 (Fair)	Long Irregular	Spreading (S)
11	PGA 14442-1	Cordate	Purple	Green with	Light Green	Green	Pink	Yellow	1 (Excellent)	1 (Excellent)	Long Elliptic	Spreading

				purple veins								
12	Butter milk	Cordate	Green with tinged purplish margin	Green	Green pigmented at leaf neck and node	Green tinged brown	Cream	Yellow	1 (Excellent)	1 (Excellent)	Long	Spreading (S)
13	PGA 14011-43	Triangular	Purple	Light green	Green	Green	Brownish orange	Pink	2 (Very Good)	2 (Very Good)	Long elliptic	Extremely spreading (ES)
14	PGA 14398-4	Triangular	Purple	Light green tinged purple at leaf edge	Green tinged purple	Green tinged purple	Pink	Cream	7 (Poor)	7 (Poor)	Long elliptic	Extremely spreading (ES)
15	Cri-Dadanyuie	Triangular	Green	Green	Light green	Green	Pink	Cream	5 (Fair)	5 (Fair)	Long elliptic	Semi-Erect (SE)
16	Local Best	Triangular	Green, tinged purple at margin	Light green tinged purple at margin	Green tinged purple	Light green	Yellow	Cream	5 (Fair)	5 (Fair)	Round elliptic	Extremely spreading (ES)
17	PGA 14372-3	Hastate	Green with tinged veins	Deep green	Green tinged purple	Purple	Purple	Cream	3 (Good)	3 (Good)	Round	Spreading (S)
18	Cri-Okumkom	Hastate	Purple	Green	Light green	Green	Pink	Orange	5 (Fair)	5 (Fair)	Curved	Semi-erect (SE)
19	PO3/35	Lobed	Green tinged purple	Deep green	Light green	Light green	Pink	Cream	7 (Poor)	7 (Poor)	Ovate	Semi-erect (SE)
20	PGA 14351-4	Lobed	Deep green	Green	Purple	Purple	Orange	Orange	7 (Poor)	7 (Poor)	Round	Spreading (S)
21	UMUSPO/3 (Check)	Hastate	Deep green	Light green	Purple	Purple	Orange	Orange	2 (Very Good)	2 (Very Good)	Round Elliptic	Extremely Spreading (SE)

22	TU-Purple	Hastate	Purple	Purple	Green tinged purple	Purple	Purple	Dark purple	5 (Fair)	5 (Fair)	Round	Spreading (S)
23	PG17265-NI	Lobed	Purple	Purple	Green tinged purple	Green	Pink	Orange	3 (Good)	5 (Fair)	Long elliptic	Extremely Spreading (ES)
24	Nwoyorima	Lobed	Purple	Deep green	Green tinged purple	Green tinged purple	Yellowish	Pale orange	7 (Poor)	7 (Poor)	Ovate	Extremely spreading (ES)
25	PO3/116	Lobed	Light green with purple veins	Green	Green	Purplish brown	Purple-red	Orange	5 (Fair)	5 (Fair)	Long irregular	Spreading (S)

Table 2: Growth and yield components as influenced by sweet potato genotypes in Uyo, Nigeria

S/N	Sweet potato genotypes	Plant Attributes									
		Vine length (cm)	No. of leaves	Unit Leaf area (cm^2)	No. of branches	Top biomass (kg/plant)	Length of root tubers (cm)	Circum. Of root tubers (cm)	No. of storage roots/plot	Stands at harvest	Storage root yield (tha^{-1})
1	PGA 14008-9	228.6^{h}	48.6^{d}	37.60^{e}	5.2^{c}	1.5^{b}	19.0^{d}	12.0^{e}	15.2^{f}	7.0^{c}	8.6^{f}
2	OBARE	212.4^{hi}	56.4^{l}	23.03^{h}	5.4^{c}	0.5^{e}	14.4^{e}	11.2^{e}	18.4^{e}	7.2^{c}	7.3^{f}
3	KWARA	120.4^{k}	81.8^{h}	1.17^{k}	5.2^{c}	0.4^{ef}	14.2^{e}	22.1^{c}	3.0^{i}	6.3^{cd}	1.8^{i}
4	NAN	47.6^{n}	38.6^{k}	0.7^{i}	2.6^{de}	0.2^{f}	20.6^{cd}	18.0^{cd}	2.6^{i}	3.4^{e}	2.6^{h}
5	Cri-Apomuden	230.2^{h}	59.4^{i}	0.7^{b}	3.4^{d}	0.3^{ef}	24.5^{c}	13.2^{e}	33.4^{c}	5.2^{d}	7.6^{f}
6	PG17362-NI	70.6^{m}	52.4^{i}	15.51^{i}	3.6^{d}	0.3^{ef}	25.2^{c}	14.2^{d}	5.2^{i}	5.2^{d}	4.9^{g}
7	87/OP/195	180.6^{i}	146.8^{e}	42.39^{d}	10.2^{a}	1.2^{c}	22.6^{cd}	31.0^{a}	25.4^{d}	12.4^{a}	48.9^{a}
8	PGN 16021-39	200.4^{i}	27.6^{l}	29.61^{g}	6.2^{c}	0.3^{ef}	16.4^{de}	12.4^{e}	4.0^{i}	9.4^{b}	4.3^{g}
9	CEMSA 74-228	125.2^{k}	18.6^{m}	1.53^{k}	6.6^{c}	0.2^{ef}	1.4^{g}	1.7^{h}	12.2^{g}	8.2^{c}	13.6^{ef}
10	TIS 87/0087 (check)	100.8^{l}	111.4^{g}	45.12^{d}	6.3^{c}	0.3^{ef}	15.6^{e}	10.0^{k}	13.2^{g}	8.2^{c}	11.6^{e}
11	PGA 14442-1	201.4^{i}	139.3^{f}	46.9^{cd}	10.4^{a}	1.4^{b}	18.4^{d}	26.4^{b}	27.4^{d}	7.2^{c}	41.6^{b}
12	Buttermilk	230.4^{h}	21.5^{m}	1.56^{l}	8.8^{b}	0.4^{ef}	20.2^{cd}	18.2^{cd}	13.6^{g}	6.2^{cd}	30.9^{c}
13	PGA 14011-43	200.6^{i}	76.4^{h}	0.88^{k}	8.4^{b}	0.67	8.6^{f}	6.2^{g}	13.2^{g}	5.6^{d}	31.9^{c}
14	PGA 14398-4	640.4^{a}	149.3^{de}	6.02^{i}	4.6^{cd}	1.0^{cd}	10.4^{f}	7.2^{g}	15.4^{f}	6.4^{cd}	3.6^{h}
15	Cri-Dadanyuie	400.2^{d}	159.6^{d}	1.32^{k}	5.6^{c}	1.2^{c}	2.6^{cd}	10.3^{f}	4.6^{i}	4.2^{d}	8.6^{f}
16	Local Best	2.26^{i}	44.6^{i}	48.64^{c}	5.6^{c}	1.2^{c}	20.6^{cd}	26.6^{b}	46.0^{b}	6.2^{cd}	18.6^{d}
17	PGA 14372-3	39.4^{f}	53.4^{i}	54.80^{b}	8.4^{b}	1.1^{c}	25.2^{c}	30.4^{a}	77.2^{a}	6.2^{cd}	18.3^{d}
18	Cri-Okumkom	511.6^{b}	204.2^{c}	33.24^{f}	3.2^{d}	0.65^{e}	18.4^{d}	215.4^{d}	8.6^{h}	6.2^{cd}	8.9^{f}
19	PO3/35	56.4^{n}	16.6^{m}	0.62^{l}	0.8^{e}	0.3^{ef}	20.6^{cd}	16.6^{d}	2.3^{i}	6.6^{cd}	0.6^{j}

20	PGA 14351-4	277.4^{g}	48.2^{j}	51.27^{b}	3.4^{d}	0.6^{e}	38.4^{a}	15.4^{d}	7.1^{h}	6.2^{cd}	4.0^{g}
21	UMUSPO/3 (Check)	400.6^{d}	53.6^{j}	62.04^{a}	8.6^{b}	0.6^{e}	17.4^{d}	15.4^{d}	19.6^{e}	9.2^{b}	17.3^{d}
22	TU-Purple	306.0^{f}	102.6^{g}	39.95^{e}	2.6^{de}	0.5^{e}	14.4^{e}	10.2^{f}	18.2^{e}	10.2^{b}	2.0^{j}
23	PG17265-NI	350.4^{e}	150.4^{de}	50.76^{c}	4.2^{cd}	0.6^{e}	30.6^{b}	9.6^{f}	12.2^{g}	9.4^{b}	5.0^{g}
24	Nwoyorima	450.0^{c}	230.2^{b}	41.45^{e}	7.8^{b}	2.9^{a}	39.9^{a}	20.4^{c}	13.4^{g}	8.6^{c}	13.3^{e}
25	PO3/116	220.6^{h}	305.6^{a}	33.84^{f}	5.4^{c}	0.9^{d}	17.6^{d}	20.1^{c}	15.4^{f}	7.6^{c}	3.6^{h}
		5804.46	**2397.1**	**670.65**	**142.5**	**19.22**	**477.2**	**594.2**	**426.8**	**178.5**	**319.4**
	$\overline{X}$	**232.17**	**95.88**	**26.82**	**5.7**	**0.76**	**19.08**	**23.76**	**17.07**	**7.14**	**12.77**
	Range	**47.6-640.4**	**16.6-305.6**	**0.62-62.04**	**0.8-10.4**	**0.2-2.9**	**1.4-39.9**	**1.7-30.4**	**2.3-77.2**	**3.4-12.4**	**0.6-48.9**

Analysis Of Fish Consumption Behaviour In Ikot Ekpene Local Government Area Of Akwa Ibom State, Nigeria

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Abstract: *This study examined fish consumption behavior in Ikot Ekpene Local Government Area of Akwa Ibom State. A structured questionnaire was used to generate primary data from 120 respondents. A multi-stage sampling technique was employed in the selection of respondents. The data were analyzed using descriptive statistics and multiple regression model. The result revealed that most of the respondents accounted for about 59.2% were female; most of the households (54.2%) had 2-4 persons with most of them (80.8%) between 15-50 years. About 83.3% of the respondents had one form of formal education or the other with 45.8% as traders primarily and 26.7% civil servants. The analysis further showed that 25% earned between ₦25,000 and ₦50,000 monthly. The result of the regression analysis revealed that quantity of fish consumed monthly was positively affected by monthly expenditure on fish and household size. The coefficient of determination (R^2) of 0.461 implies that 46.1% of the variation in the quantity of fish consumed monthly was explained by variables in the regression model. The coefficient of household size, was significant at 10% probability level and monthly expenditure on fish was significant at 1%. Consumers preferred dried fish more than any other fish form and the major constraints to fish consumption in the study area were found to be; high spoilage of fish, limited resources, high price of fish and lack of storage facilities. With high preference for dried fish, fish farmers should take advantage of the market, increase its production and add value to their product. Good storage facilities should be provided and fish value chains should be effectively and efficiently managed especially in the area of fish smoking/drying and refrigeration.*

Key word: Fish Consumption, Preference Behaviors, Analysis,

CITATION:
Effiong, E. O., Camillus, E. E. and Etim, S. M. (2023). Analysis of Fish Consumption Behaviour in Ikot Ekpene Local Government Area of Akwa Ibom State, Nigeria. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 415-421

Introduction

Fish is a key ingredient on the global agenda and integrated into thinking, action and policies at the highest level of all nations. (NAGA, World Fish, 2015). Fish among all other important protein foodstuffs such as eggs, milk, meat and other animal product constitute an excellent source of protein of high biological value. (Amao et al, 2014). Fish and sea food product were recommended to take a prominent position in the human diet due to their beneficial role in the prevention of chronic degenerative diseases. The role of fish towards reducing poverty and hunger is well recognized. (Madhavi and Kasuma, 2015). It is widely envisaged that in many countries, people derive more than 50% of their daily animal protein requirement from fish. Fish has low cholesterol compared with red meat and because of its ease of digestibility as well as soft tissue and high nutritional value it is highly recommended for both the young and the old (Eyo, 2002).

Fish and fish products are known worldwide as quality and significance in improving human health. (Akinbode et al 2011). To meet the demand for fish protein in Nigeria, an increase by one million tonnes of fish per annum is required (Ugwumba, 2013). Fish is economically, socially and culturally important as a global dietary aspect of sustainable food security. Nigeria is experiencing deficit of about 2.17 million metric tonnes which is required to meet the ever-increasing demand augmented by massive importation in millions of foreign exchange Central Bank of Nigeria, 2015. Fish consumption has undergone major changes in the past four decades. In essence, per capita fish consumption has been increasing steadily from an average of 9.9 kg in the 1960's to 11.5 kg in the 1970's, 12.5 kg in the 1980's 14.4kg in the 1990's, 16.4kg in 2005, 19.7kg in 2013 with preliminary estimates for 2014 and 2015 pointing towards further growth beyond 20kg CBN, (2015). Although, annual per capita consumption of fish has grown steadily in developing regions but still considerably lower than that in more developed regions, even though the gap is narrowing.

In 2013, per capita apparent fish consumption in industrialized countries was 26.8kg reference. The significant growth in fish consumption has enhanced people's diets around the world through diversified and nutritious food. In 2013, fish accounted for about 17% of the global populations' intake of animal protein and 6.7% of all protein consumed. Moreover, fish provided more than 3.1 billion people with almost 20% of their average per capita intake of animal protein. (The State of World Fisheries and Aquaculture, 2016). Fish consumption depends on several factors such as increasing population along with sufficient supply of fish and fish products, demand, income, educational level, consumer preference and fish prices.

The extent to which Nigerians face the protein shortage problem calls for an urgent solution. In 1991, the Federal Ministry of Health indicated that malnutrition is the most serious health problem which directly hinders growth and development of the economy. This is because there is a great disparity between the required animal protein intake and the actual consumption. Most low income households assume that fish is meant for the adult members of the family, hence nutrition problems still persist most especially among the young ones. Recent surveys show that one out of five persons is undernourished and that hunger, malnutrition and serious health problems are still inherent in many parts of Nigeria. (Okunola,2011). The total demand for fish was estimated at 1,150 million metric tonnes in 1979 and this increased to 1,450 million metric tonnes in 1988, (Lamorde, 2000). National demand in 2012 was 2,000,000 tonnes with supply of 690,000 tonnes and a deficit of 1,329,000 tonnes : in 2014, demand was 2,175,000 while supply was 730.000 tonnes leaving a deficit of 1,404,000 tonnes. (Federal Department of Fisheries,2016). It was reported that for a total consumption of 53.9 grams of protein, only 6.0 – 8.4 grams per head per day was observed among Nigerians.This falls short of Food and Agriculture Organization's minimum requirement of 65 grams of protein and 2,500k calories of energy per head per day (FAO, 1994). Out of the 800,000 metric tonnes demand, about 510,000 metric tonnes were produced locally leaving the deficit to be met by importation of frozen fish, canned and stock fish, in spite of the huge drain on the economy.However the study objectives were to identify factors influencing fish consumption and constraints as well as consumer preferences for selected fish forms in the study area.

Research Methodology

Material and Methods

Study Area: The study was carried out in Ikot Ekpene Local Government Area of Akwa Ibom State, Nigeria. Ikot Ekpene is located between latitudes 5°10 and 5°30 North and longitudes 7°30 and 7°45 East. The mean annual temperature is 90°F (32°C). The population of Ikot Ekpene according to the 2006 Nigerian Census is 143,077. The study area is commerce-oriented and predominantly inhabited by crafts men, farmers, traders, wood carvers and artisans. The town is rich in natural resources like palm produce, kernel, oil, raffia, laterite and timber. Multi stage sampling technique was used to select the respondents. In the first stage, 12 villages were randomly selected from 45 villages in the study area. The second stage involved a random selection of 10 households each from the selected villages making a total of 120 households. The data for the study were collected through a set of structured questionnaires. Both primary and secondary data was used for the study.

Analysis of data collected: In order to identify consumer preference for selected fish forms as well as the constraints to fish consumption, descriptive statistics such as frequency, means and percentages was employed. To identify the factors influencing fish consumption, multiple regression analysis was employed. This can be implicitly shown as:

$Y = bo + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + e$

bo = constant term

b_1 ……. b_7 = regression coefficients

Y = Quantity of fish consumed monthly (kg)

X_1 = Monthly expenditure on fish (Naira)

X_2 = Price of fish (naira)

X_3 = Monthly Expenditure on meat (naira)

X_4 = Household size (number of persons in the household)

X_5= Household disposable income (naira)

X_6 = Other food expenses (naira)

X_7 = Other household expense (naira). The multiple regression analysis was carried out to examine the factors influencing fish consumption behavior. Exponential function model was chosen as the lead equation because it had the highest value of magnitude (R^2) and conformed to the a-priori expectation. This is in contrast to Adeniyi, Omitoyin and Ojo (2012) when they examined socio –economic determinants of consumption pattern of fish among households in Ibadan North Local Government of Oyo State, Nigeria. state your result and discuss your results separately.

Results and Discussion

Factors Influencing Fish Consumption Behaviors in the Study Area.

Factors influencing fish Consumption behaviors in the study area is presented in Table 1 below**.** The results showed that the coefficients of multiple determination (R^2) was found to be 0.461. this implies that 46.1% of the variation in the quantity of fish consumed monthly was explained by the independent variables included in the model. The overall result however showed that two of the seven explanatory variables have significant effect on quantity of fish consumed monthly. These variables were monthly expenditure on fish and household size. This implies that the amount spent on fish is a critical factor in quantity of fish consumed in a month. In essence, an increase in monthly expenditure on fish will bring about a corresponding increase in the quantity of fish consumed in a month. This is because when monthly expenditure on fish increases, the quantity of fish consumed monthly also increases as a result. The coefficient for household size had a positive sign and was statistically significant at 10% probability level. This implies that as household size increase, the quantity of fish consumed monthly will increase. Therefore, a unit increase in these factors will lead to an increase in quantity of fish consumed monthly by the coefficient of the respective

variables. Moses *et al*., (2015) however stressed consumer preferences for fish are determined by income, age, educational qualifications and household size which fall in line with some of the variables under study. Onurlubus (2013) using logit model to analyze the factors affecting families fish consumption however stressed that age, gender and the number of individuals in the family affect families fish consumption The other variables were not statistically significant at any level even though the unit price of fish (X_2) and monthly income (X_5) had negative relationship while monthly expenditure on meat (X_3), other food expenses(X_6) and other household expenses (X_7) had a positive relationship with the quantity of fish consumed monthly. With respect to consumer preferences for selected fish forms as shown in the table below, it was observed that majority of the respondents which accounted for 30% showed more preference for dried fish. This may be due to the fact that dried fish has the ability to be preserved for a longer period. This however implies that dried fish is mostly consumed in the study area and as such there is a greater demand for dried fish as compared to smoked fish.

Table 1. Regression Estimates for Factors Influencing Fish Consumption in the Study Area.

Production Factors	Linear Model	Semi-Log Model	Double- Log Model	Exponential model
X_0= constant	-1.015	-4.689	-0.123	0.223
	(-1.453)	(-3.655)***	(-1.106)	(3.621)***
X_1(Monthly expenditure on fish)	0.718	8.193	0.808	0.070
	(6.865)***	(6.630)***	(7.517)***	(7.613)***
X_2 (Price of fish)	-0.056	-0.726	-0.033	-0.003
	(-0.498)	(-0.623)	(-0.330)	(-0.270)
X_3(Monthly Expenditure on meat)	0.0025	0.092	-0.001	0.001
	(0.216)	(0.067)	(-0.007)	(0.150)
X_4 (Household size)	0.316	2.212	0.164	0.023
	(2.026)**	(1.884)*	(1.610)*	(1.709)*
X_5 (Household disposable income)	0.029	0.457	0.012	0.001
	(0.235)	(0.428)	(0.125)	(0.066)
X_6 (Other food expenses)	0.046	0.363	0.014	0.002
	(0.446)	(0.377)	(0.166)	(0.202)
X_7 (Other household expense)	0.190	2.091	0.179	0.016
	(1.375)	(1.527)	(1.499)	(1.338)
R^2	0.441	0.427	0.460	0.461
Adj R^2	0.406	0.391	0.427	0.428
F-ratio	12.602	11.923	13.654	13.708.

Source: Field Survey Data, 2022. **Note:** Figures in parenthesis are the respective t-ratios. *,**,*** are the probability levels at 10%, 5% and 1% respectively.

Consumer Preferences for Selected Fish Forms

Table 2, below shows consumers preference for selected fish form in the study area. Majority of the respondents (30%) showed preference for dried fish. This may be due to the fact that dried fish has the ability to be preserved for a longer period. This implies that dried fish is mostly consumed in the study area, therefore there is greater demand for dried fish as compared to smoked fish.

Table 2: Distribution of respondents based on Consumer Preferences for Selected Fish Forms.

Fish forms	Frequency	Percentages
Fresh water fish	**30**	**15**
Smoked fish	**20**	**16.7**
Dried fish	**36**	**30**
Frozen fish	**34**	**28.3**
Total	**120**	**100**

Source: Field Survey Data, 2022.

The Table below revealed that 24.2% of the consumers exceptionally like to eat fish. About 61.7% of the consumers like to eat fish very much and 14.2% of the respondents very much dislike eating fish or extremely dislikes eating fish. This implies that fish is a nutritious meal liked and appreciated by most people in the study area.Amoa and Ayantoye (2014) in their study on consumer preference and consumption pattern for selected forms of fish in Oyo State revealed that 50% of the sampled households preferred frozen form of fish, 36.7% preferred fresh water fish and 13.3% preferred smoked fish.

Table 3. Distribution of the Respondents based on Degree of preference for fish consumption

Degree of preference	Frequency	Percentages (%)
Like exceptionally to eat fish	**29**	**24.2**
Like at least very much to eat fish	**74**	**61.7**
Like at least slightly to eat fish	**17**	**14.2**
Total	**120**	**100**

Source: Field survey, 2022.

Constraints to Fish Consumption

From Table 4 below, rank 1 was considered the most severe constraints while rank 13 was considered the least severe constraints. Results from Table 4 indicates that rapid spoilage of fish prevents most of the respondents from consuming fish. The resources available was limited and as such poses a problem to fish consumption. The high price of fish was also a problem to fish consumption in the study area. However, the least constraints include the health conditions of the respondents which did not tend to hinder fish consumption, high transportation cost to place of purchase and type of fish available which could be small in nature with occasional supply of big harvest at some periods. Umaru *et al*. (2015) found out that the major problem associated with fish intake was low level of income in Michika Local Government Area of Adamawa State, Nigeria which incidentally was the study area. Other constraints identified were low supply of fish, rapid spoilage of fish as this agrees with this study.

Table 4. Constraints to Fish Consumption by Respondents in the Study Area

Constraints	Frequency	Percentage	Mean	Rank
High transportation cost to place of purchase	11	9.2	1.51	12
Availability of fish	26	21.7	1.96	5
Cheapness of the close substitute	25	20.8	1.86	10
Limited resources available	49	40.8	2.24	2
Low supply of fish	27	22.5	1.93	6.5
Type of fish available which could be small in nature with occasional supply of big harvest at some periods	21	17.5	1.73	11
Rapid spoilage of fish	58	48.3	2.32	1

High price of fish	54	45.0	2.23	3
Inadequate number of fish market	29	24.2	1.88	9
The taste of fish	31	25.4	1.93	6.5
Lack of storage facility	48	40.0	2.18	4
Small number of supplies of fish	29	24.2	1.89	8
Health conditions	8	6.7	1.32	13

Source: Field Survey Data, (2022)

Conclusion and Recommendations

In conclusion, the result of the analysis stressed that the fish form most preferred by the respondents in the study area is dried fish followed by frozen fish because of its availability. Result also indicated that expenditure on fish and household size were significant factors affecting fish consumption. The major constraints to fish consumption in the study area are rapid spoilage of fish and limited resources.

Based on the findings of the study, the following recommendations were made which include,

- The private sub- sector and individuals should be encouraged to establish fish ponds. This can be achieved by organizing workshops and trainings on fish production, processing and storage using local language especially for the local people.
- Incentives and credit facilities should be given should be given to fish farmers and fish sellers to enable them expand production capacity to meet the increasing demand. This will enable the farmers to earn higher income.
- Individuals should be encouraged to engage in various income generating activities to enable them have additional income. This will improve their consumption rate.
- To reduce fish spoilage, preserve fish quality, remove unpleasant odour and cost of processing, good storage facility should be provided and fish value chains should be effectively and efficiently managed especially in the area of fish smoking / drying and refrigeration.

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Proximate Composition Of *Monodora Myristica* Seed

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Abstract: *The study was carried out to determine the proximate composition analysis of ground seeds of Monodora myristica (African nutmeg) which was obtained from Akpan Ndem Market Uyo, Akwa Ibom State. The proximate analysis of the seeds was carried out using the standard methods. Results from the study show that the values of various parameters for the proximate composition were 8.4% moisture, 9.4% crude protein, 27.6% ether extract, 2.2% ash, 21.9% crude fibre and 30.7% carbohydrate. The study established the relatively high nutritive values of African nutmeg and recommends its exploitation.*

Keywords: Antihypertensive activity, cuisine, nutmeg oils, medicinal plant

CITATION:
Etukudoh, E. N. and Afolabi, K. D. (2023). Proximate Composition of *Monodora myristica* Seed. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 410-414

Introduction

Monodora myristica is a perennial edible plant of the *Annanacea* family, which grows in the evergreen forest of West Africa (Burubai *et al.,* 2009). It is widely distributed from Africa to Asia, central and South America (Omobuwajo *et al.,* 2003). *M. myristica* has its common names as African nutmeg, calabash nutmeg and in Nigeria, it is called "Ehuru" in Igbo, "Abolakosha" in Yoruba and "Ebenoyoba" in Benin (Akinwunmi and Oyedepo, 2013). In addition, the bark, seeds and leaves are used in treating various ailments in African traditional medicine (Erukainure *et al.,* 2011). However, the most economical important parts are the seeds which are embedded in the white sweet smelling pulp of the sub-spherical fruit (Hemingway, 2004). The seeds have nutritive and calorific values, which makes them necessary in diets (Odemelam, 2005). The kernel obtained from the seed has an aromatic fragrance, which makes it suitable as a spicing agent for both African and Continental cuisines in Nigeria (Dike, 2010). In eastern countries, it is used as drug more than a condiment. When it was roasted and grounded, seeds are rubbed on the skin for treatment of skin diseases (Irvine, 2000). This suggests that the seed of *M. myristica* plant could be germicidal or antiseptic (Rancy and Krishnakumari, 2015). It can be used for the treatment of constipation and as a stimulant (Irvine, 2000). Grinding into powder, the seed may be taken as a stimulant to relieve constipation and control passive uterine hemorrhage in women immediately after child birth (Udeala, 2000). The essential oil from the seed is used in pharmaceutical and dental preparation (Talalaji, 1999), the stem and bark of *M. myristica* is used in the treatment of haemorrhoids, stomach ache, fever pains and eye diseases (Singh *et al.,* 2005). The nutrient contents of the seed from different locations have been reported (Burubai *et al.,* 2009; Dike,

2010; Ekeanyanwu *et al.,* 2010). In southern Nigeria, very few people have the knowledge that *M. myristica* apart from serving as a flavouring agent, it has other importance benefits. This study therefore aimed at determining the proximate compositions of *M. myristica* seeds.

Materials and Methods

Plants Materials

Dried *Monodora myristica* seed

Collection of Plant Material

Fresh seeds of *Monodora myristica* were bought at Akpan Ndem Market in Uyo, Akwa Ibom State.

Equipment and Instruments

All apparatus used in this study were obtained from the Kappa laboratory, Bodija, Ibadan, Nigeria.

Preparation of Plant Material for Analysis

Fresh seeds of *M. myristica* were cleaned to get rid of bad seeds and dirt. The seeds were then taken to the local mill where it was milled to fine powder using manual engine grinder.

Proximate Analysis

The proximate analysis of the sample for moisture, crude protein, fat, ash, carbohydrates and fibre contents were carried out using AOAC (2000) official methods.

Results and Discussion

Table 1: Proximate Composition of *Monodora myristica* seed meal

Proximate Parameters	Composition (%)
Moisture	8.4
Protein	9.4
Ether Extract (fat)	27.6
Ash	2.2
Crude fibre	21.9
Carbohydrates	30.7

Source: Field result

Even though the seeds are used as spices, the carbohydrate and lipid contents as shown in Table 1. It was quite appreciable and could be regarded as good sources of carbohydrate and especially essential oils for the body. The antihypertensive effect of essential oils derived from seeds of *M. myristica* have earlier been studied (Roudou *et al.,* 2007). The phytochemical analysis of seeds of *M. myristica* show its essential oil contains mainly monoterpeniods, which indicate that it exerts an antihypertensive activity. Essential oils derived from the cotyledons of such seeds, showing high saponification value, low iodine and acid values. Therefore, it could be used for their medicinal and antioxidant properties (Ayelaagbe *et al.,* 1996).

The ether extract with 27.6% is in line with the report of Faleyimu and Oluwalana, (2008) who reported 25.00%; 29.10% - Ekeanyanwu *et al.,* (2010), 22.70% - Anabulela *et al.,* (2014) and Enwereuzoh *et al.* (2015). Fat is important in diets because it promotes fat soluble vitamins absorption (Okwu, 2001). The crude protein (CP) of 9.4% for seeds of *M. myristica* corresponds to 12.00% value reported by Faleyimu and Oluwalana (2008), 10.13% in Ekeanyanwu *et al.,* (2010) and 9.60% in Enabulele *et al.,* (2010). However, the obtained value (9.4 % CP) is at variance with 22.77% and 18.69% reported separately by Ugwona, (2014) and Enwereuzoh *et al.,* (2015), respectively. Such differences may arise from variations in soil micronutrients (Okwu, 2001) or methods of analysis. The crude protein value is relatively low when compared to protein rich foods, such

as soya beans, cowpeas, pigeon peas, melon and gourd seeds that ranged between 23.1 and 33.0% (Olaofe *et al.,* 1994). However, it could be a good source of important enzymes which is the form on which is most proteins in spices (Wills *et al.,* 1998). The recommended daily allowance for protein for children ranges from 23.0 – 36.0 g and 44.56 g for adults (NRC, 1989). Apart from the significant nutritional protein as a source of amino acids, they also play a part in the organoleptic properties of food (Aremu *et al.,* 2006). Amount of 8.4% for moisture was in concurrence with the report of Ugwuona (2014) - 8.68%, Enwereuzoh *et al.,* (2015) - 6.00% but this value is lower than those obtained by Faleyimu and Olwalana (2008) - 10.00%, Ekeanyanwu *et al.,* (2010) - 13.15% and Enabulele *et al.,* (2014) 11.20%.

The difference observed may be as a result of the maturity of seed as well as the method of analysis used. Amount of the moisture was comparable with that of legumes ranging between 7.0 and 11.0% which reported by Aykroyd and Doughty (1964). The low moisture content is indicative of the fact that African nutmeg can be stored for a long period without deterioration in quality or microbial spoilage since microbial activity may be reduced to a minimum level. Moisture content of any food can be used as an index of its keeping quality. Water is an important media for most biochemical reactions. Food samples with 15% for water content are more prone to high biochemical activities. Therefore, it usually has short shelf life (Joslyn, 1970).

The ash content of 2.2% corresponds to the observation of 3.90% and 2.50% by Ekeanyanwu *et al.,* (2010) and Enabulele *et al.,* (2014), respectively. The ash content of 4.90%, 5.00%, and 8.61% for seeds of *M. myristica* reported by Enwereuzoh *et al.,* (2015), Faleyimu and Oluwalana (2008) and Ugwona (2014), respectively, were higher than those of this study. Consequently, this could be caused by changes in the climatic factors in addition to edaphic factors. The ash value for seeds of *M. myristica* was very low, slightly lower than that of *Brachetagia eurycoma* (8.35%). Pomeranz and Clifton (1981) recommend that ash content of nuts, seeds and tubers should fall within the range of 1.5 – 2.5% in order to be suitable for animal feeds. The ash content of African nutmeg seed falls within this range. Therefore, it can be recommended for animal feeds. Ash content refers to the inorganic residues which remained after either ignition or complete oxidation of organic matter in the sample, and gives an overview of mineral content of the material (Joslyn, 1970). High amount of ash implies high mineral contents in the spices. *Monodora myristica* is not likely to be a good source of mineral in human or animal diet. Nutritionally, ash aids in the metabolism of protein, carbohydrate and fat (Okaka, 2005).

Amount of 21.9% for crude fibre content was corresponded to the report by Enabulele *et al.,* (2014) 19.10% but it was vastly different from the reports by Faleyimu and Oluwalana (2008) 8.33%, Ekeanyanwu *et al.,* (2020) 25.90%, Ugwuona (2014) 5.25% and Enwereuzoh *et al.,* (2015) 3.30%. The variation of the results may be caused by changes in climatic factors and stage of maturity of seed used. However, the fibre content observed in this study is relatively of higher quantity. This implies that when this seed is incorporated into feed, it will help to prevent many metabolic or digestive disorders such as constipation and irritable bowels etc. (Akinlawon, 1998). The content of the crude fibre was very high compared to legumes, which was ranged between 5 and 6% (Aremu *et al.,* 2006). Therefore, African nutmeg is a good source of dietary fiber. Dietary fibres are generally plant polysaccharides that cannot be digested by human digestive enzymes. Dietary fibres are either soluble or insoluble, both modulate physiological function and prevent some

degenerative diseases in animals. Dietary fibre causes variations of water content in faeces, faecal bulk, transit time and elimination of bile acids and neutral sterols, which lowers the body cholesterol pool. Therefore, the dietary fiber has been shown to reduce the incidence of coronary and breast cancer (Effiong *et al.,* 2005; Lintas, 1992).

The percentage carbohydrate content of *M. myristica* seeds was 30.7% in this study. This value is in concurrence with the reports by Faleyimu and Oluwalana (2008) and 28.40% reported by Enabulele *et al.,* (2014); but different from 21.2%, 42.78% and 46.90% reported by Ekanyanwu *et al.,* (2010), Enwereuzoh *et al.* (2014), and Ugwuona (2014), respectively. The variations in the carbohydrate values may be attributed to the method of analysis of the components. The carbohydrate content was higher than that of cassava seed (16.81%) (Akinlawon, 1998) and falls within the acceptable range for legumes (20 – 60 %) based on dry weight (Aykroyd and Doughty, 1964). Hence, seeds are good source of energy for animals when they are incorporated into diet. Carbohydrate provides energy to cells, particularly the brains, which depended on the carbohydrate content (Effiong *et al.,* 2005).

Conclusion

The relatively high nutritive values of African nutmeg may be of little importance in feed mill industry since the quantity of this spice in use in animal feed is relatively very small. African nutmeg is consumed as food ingredients in low quantities, and its contribution to nutrition in diet may not be as high as the conventional feed items. However, many rural consumers use *M. myristica* seed flour copiously in various local dishes. Hence, it can make meaningful nutritional contribution in human and animal diets. Generally, it contributes to food cuisine nutritionally and imparts many health benefits. Conclusively, it should be noted that the seeds of *M. myristica* contained some important nutritional components.

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Emerging Food Environments And Implications For Attaining Sustainable Development Goals In Africa

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Abstract: *Food environment consists of the interphase where consumers interact with the larger food systems to acquire food needs. Within this interphase, the retail food environments play the role of creating avenue for consumers to acquire foods. The identified retail environments in Africa present consumers with assorted options, but the formal markets seem to promote over consumption of processed and packaged food products. The resulting consumption patterns are those that promote food insecurity, obesity and other problems of nutrition transition, thereby negating the aim of the Sustainable Development Goals on nutrition within the region. It is therefore needful to take advantage of policies that can create healthier food environments through retail food outlets to ensure appropriate consumption patterns.*

Keywords: Food Environments, Retail Food outlets, Africa, Sustainable Development Goals, Food Security

CITATION:
Ekerette, N. N. and Udo, A. U. (2023). Emerging Food Environments and Implications for Attaining Sustainable Development Goals in Africa. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 401-409

Introduction

Recently, the place of food systems in solving the world's food and nutrition problems is receiving much attention, stemming from the recognition that, it can be manipulated to produce all conditions and processes essential for ensuring food security and nutrition for the world's teaming population. The activities, processes and determining factors related to the eventual acquisition and consumption of food, starting from production and extending to all other components of the food supply chain has been recognised to influence what people eat, the resultant physiological outcomes, effects on health and the overall quality of life.

Population growth and recent advances in technology have greatly altered the food production systems, processing, preservation and marketing. Changes in lifestyles, resulting mostly from time constraints on the part of consumers, have also created a demand system that drives innovations in food production to those presenting consumers with wide range of food options and often in their most convenient forms (Hueston and McLeod, 2012; Reardon *et al*., 2021). The Food and Agriculture Organisation defines food environment as essentially the context in which acquisition and consumption of food occurs, providing a series of opportunities and constraints that influence decisions about what to eat (FAO, 2016). It simply consists of the interface through which consumers interact with the larger food system to acquire foods (Turner *et al*., 2017).

In Africa, food acquisition was based primarily on indigenous food culture and knowledge, some of which included small scale farming, gathering from the wild and exchange

of goods (Abrahams *et al*., 2011; Masekoameng and Molotja, 2019). Thus, the typical African diets were based on unprocessed staples, with minimal consumption of refined food items (Abrahams *et al*., 2011; Popkin *et al*., 2012). This consumption pattern though, exerted its own nutritional problems, especially those related to protein deficiency (e.g., protein-energy malnutrition) as diets rarely included good quality protein sources. Micronutrient deficiencies were also rampant in the region, all resulting in compromised immunity and infectious diseases (Abrahams *et al*., 2011). Urbanization, brought about by industrialization later on promoted importation of foreign food cultures, especially those consisting of increased consumption of processed and energy dense meals. This transition in dietary intakes, has not only brought in changes in dietary intake patterns, but is also accompanied by various diet-related non-communicable disorders. The nutritional problems in Africa now consist of the coexistence of under-nutrition and the problems of excess energy intakes, leading to a scenario referred to as the double burden of malnutrition (Abrahams *et al*., 2011; Vorster *et al*., 2011; Bosu, 2015). The challenge lies in the fact that, the Sub-Saharan Africa is least prepared to tackle and proffer solutions to its many developmental problems, including malnutrition (Beal *et al*., 2017).

The United Nations recently proposed a set of 2030 Sustainable Development Goals (SDGs), as a build-up on and continuation of the Millennium Development Goals, with the overall aim of eradicating poverty and enhancing developments across all regions in the world (United Nations, 2015). Two out of the seventeen goals have nutrition components, goal two "end hunger, achieve food security and improved nutrition and promote sustainable agriculture" and goal twelve "ensure sustainable consumption and production patterns". The issues of hunger and food insecurity constitute potential barriers to national development all over the world. Within these goals are targets that deal directly with the issues of increasing access to safe, nutritious and sufficient foods all-round the year. Retail food outlets play a role in providing a platform for physical access to foods. This work seeks to describe the existing food environments in Africa, with particular emphasis on retail food outlets, their contributions to prevalent food consumption patterns and how these consumption patterns comply with the recommendations in the SDGs regarding nutrition.

The Concept of Food Environment

Based on the type of food sources, Downs *et al*., (2020) in their exposition on food environment typology, differentiated between two types of food environments. First, the natural food environment which includes wild (where humans acquire foods from wild and uncultivated physical environments – forests, jungles, and natural water bodies including rivers, streams, lakes and ponds), and cultivated (where consumers acquire foods from cultivated lands including gardens, subsistence farm lands, and aquaculture etc). Natural food environments present opportunities where consumers can have direct access to acquire foods without the influence of most components of the food supply chain. Secondly, the built food environment comprises of informal and formal settings. Informal food environment consists of those sales outlets operated without strict government regulations and include traditional open or wet markets, convenience stores, mobile and street vendors. Supermarkets, restaurants, retail stores, institutional and public procurements are operated with strict monitoring and regulations by government agencies and are referred to as formal food environments.

Food environment can be viewed at various levels - the community nutrition environment;

within-store consumer food environment and organisational nutrition environment (Glanz *et al*., 2007). Community nutrition environment gives information on the types and number of food sources within location. Within-store consumer food environment depicts the variety, quality, and price and nutrition information of food items sold at the individual retail outlets. Organisational nutrition environment describes the food environment at the institutional level such as home, workplace, schools etc. The Agriculture, Nutrition and Health (ANH) Food Environment Working Group (ANH-FEWG) compartmentalized food environments in two domains –external and personal food environments (Turner *et al*., 2017). External food environment consists of external influences beyond the consumers' domains that characterize the prevalent food environment and include food availability, prices, vendor and product properties, and marketing and regulation. Personal food environment describes those perspectives that are within the consumer's domain, and include accessibility, affordability, convenience and desirability (Turner *et al*., 2017).

The dimensions - availability, sustainability, convenience, affordability, and quality are equally important elements of food security. Food availability deals with the types, quantity and varieties of food present within a particular food environment and can be influenced by several factors including the physical, ecological, socio-ecological conditions etc. Food choice in this instant can be influenced first by the physical environment – home, school, work place due to the types of foods found in such environment (Akinseye *et al*., 2012; Akinseye and Vincent, 2013; Micha *et al*., 2018). The extent to which consumers can access, acquire and consume foods is influenced by the food cost. Some, particularly foods harvested from the wild and those cultivated through small scale farming may be affordable especially to the low income groups, whereas, those obtained from the built environment, including processed and packaged foods are more expensive. The time and physical energy invested in getting foods measure how convenient it is to acquire certain foods. For instance, improved physical infrastructures can mean easy access to local markets.

Food Environments in Africa: The Retail Food Outlets

Food environment in Africa has changed considerably over the past years, with the built environments growing at a fast rate (Demmler and Qaim, 2020). This is indicated by the number of shopping malls springing up in a location within the shortest period of time (Khonje and Qaim, 2019). Within the African region, it is noted that the food environment is characterized by coexistence of both formal and informal retail food establishments, with each competing for dominance in various settings. Spires *et al*., (2020) in their work using the Environmental Profile of a Community's Health (EPOCH) tool to map food environment in three countries observed that, although there were more informal retail food outlets in two African countries - Uganda and South Africa, the number of supermarkets and fast food outlets operating in each country far outweighed the number of such establishments found in Sweden. Both formal and informal food environments are widely patronized in the African setting. Besides they seem to serve different purposes, in terms of the types of food presented to consumers. For instance, individuals and households may choose to patronize supermarkets to purchase a range of processed food items that may not be sold in the local traditional markets (in quantities, quality and options available), but choose to buy the bulk of household food needs, especially the fresh produce and other unprocessed foods from the more informal markets (Khonje and Qaim, 2019). However, the choice of retail food

outlets depends on several other factors, other than the type of foods sold in retail outlets. This include household income and the socioeconomic status in general (Khonje and Qaim, 2019). Consumers tend to buy less from the traditional markets as income increase, while low income households acquire most of their foods from traditional and other less informal markets (Khonje and Qaim, 2019).

The most popular food sales outlets in Africa include supermarkets, kiosks, traditional wet markets and street food vendors (Wanyama *et al*., 2019; Annan *et al*., 2022). Each outlet is popular for the types of food stuff presented to the consumers. For instance, traditional markets constitute the most important source of unprocessed local food products and ingredients. (Annan *et al*., 2022; Khonje and Qaim, 2019). Spires *et al*., (2020) noted that the traditional market offered most of the vegetables in Uganda when compared to other retail outlets. This makes it the most important market in the region that supplies households with good proportion of their food needs. Because of the influx of foreign food cultures, several processed food items are also being sold in these markets (Annan *et al*., 2022). In terms of commodity prices, traditional markets are most likely to present food products at the cheapest rates (Spires *et al*., 2020).

Supermarkets are also seen as important food sales outlets in most African settings, especially in the urban centres. Perhaps, the wide popularity and acceptability accorded supermarkets in the region stem from the fact that, consumers can easily make choices from the wide range of options provided at affordable prices. Spires *et al*., (2020) noted that, although supermarkets offered the widest range of food items in South Africa and Uganda, commodity prices were not necessarily higher than those obtained from other retail outlets (Spires *et al*., 2020). The tendency is that, due to better service delivery and aesthetics often associated with formal food environment settings, consumers may prefer patronising supermarkets since commodities can be purchased at similar prices as sold in other retail outlets. Supermarkets supply mostly processed foods, including those made from cereals (bread, breakfast cereals, biscuits and other snacks); beverages including alcoholic and non-alcoholic drinks; milk and dairy products; fat sources (such as fat, oils, margarine etc); spices and other ingredients; canned and frozen vegetables, fruits, fish and meat. The sales of fresh produce in supermarkets is also gaining grounds than before, though they are sometimes of poorer quality (Wanyama *et al*., 2019; Mockshell *et al*., 2022). Fruits and vegetables may be left to stay longer in supermarkets as consumers prefer buying them from traditional markets – a cheaper source of produce at higher quality, thereby leaving those in the supermarkets to take longer than necessary to get sold out (Spires *et al*., 2020). This also depend on the particular supermarket, as some may have better storage and preservation facilities that prolong the shelf life of fresh produce than others (Odunitan-wayas *et al*., 2020).

In Ghana, convenience stores were reported to offer higher range of processed foods and patronage than supermarkets (Annan *et al*., 2022). Another common food outlet are the neighbourhood kiosks. They are mostly situated within residential areas and offer food items similar to those sold in supermarkets, but in lesser varieties and quantities (Mockshell *et al*., 2022). By reason of its low cost, convenience, product palatability and time sparing, street food vending now constitutes popular food sources, especially among the low income urban dwellers in Africa (Dada, 2016; Leshi and Leshi, 2017; Annan *et al*., 2022). They provide street ready to-eat foods, fruits, and vegetables to the teaming populations. Since street foods are not limited in the range of foods provided (full

meals, deserts, snacks and beverages) it is popularly patronized by people of all age groups. They are consumed at all times of the day, such that, consumers can take any or all of the three traditional meals-breakfast, lunch or dinner (Annan *et al*., 2022; Leshi and Leshi, 2017).

Influence of Food Environments on Dietary Intake Patterns

The type of foods consumed and the overall dietary intake patterns is determined by several factors including the existing food environment. The retail food outlets have their own place in presenting foods that consumers have direct access to. For instance, studies indicate that, increased consumption of processed and ultra-processed foods is associated with supermarket patronage (Demmler *et al*., 2017). Processed and ultra-processed foods are mostly energy dense from added fats and sugar. Moreover, they are also high in sodium, little wonder consumers are at higher risk of obesity and other diet related diseases.

However, consumption of processed food products, especially meat, fish, dairy products, sugar, sweets, and sweetened beverages are not limited to supermarket purchase, as these items are also sold in neighbourhood kiosks, convenience and grocery stores as well as traditional markets (Annan *et al*., 2022; Khonje and Qaim, 2019). Sometimes they may be consumed in higher amounts and frequency when purchased from informal settings than when acquired from the supermarket (Khonje and Qaim, 2019). This corroborates the observation that, the choices of foods purchased from any retail food outlet could be influenced by factors other than the types of foods sold in respective outlets. Odunitan-wayas *et al*., (2020), noted that socioeconomic status greatly influenced the types of food materials purchased by consumers. Consumers at higher socioeconomic areas were found to purchase more fruits, vegetables, eggs, dairy and bread from supermarkets, while their counterparts in lower socioeconomic status spent more buying grains, potatoes, snacks and sugar sweetened beverages than what was spent buying fruits and vegetables from supermarkets, (Odunitan-wayas *et al*., 2020). Moreover, because of the wide range of foods sold at the supermarkets, purchasing foods from supermarkets has been linked to increased dietary diversity (Demmler *et al*., 2017; Demmler and Qaim, 2020).

The significant contributions of street foods to energy and nutrients intakes - energy, protein, as well as selected micronutrients such as iron and vitamin A have been recognized (Steyn et al., 2013; Nwankwo, 2021). They also have the potential of enhancing good dietary intake patterns through dietary diversity as they are prepared to include foods from diverse sources - cereals, legumes, roots and tubers, as well as within-group protein sources such as dairy products, meat, fish and egg (Nwankwo, 2021). Based on the fact that, no one food contains all essential nutrients, and that combining foods from different sources allows foods to complement each other in providing the nutrients that are in short supply, dietary diversity has been recognised as one effective means of ensuring good quality diets. Hence, most dietary guidelines recognize and recommend consumption of diverse food ingredients drawn from across and within major food groups (U.S. Department of Health and Human Services and U.S. Department of Agriculture, 2015). Leshi and Leshi, (2017) however reported low dietary diversity among street food consumers in South-west Nigeria. It is however feared that street food consumption can lead to obesity and diet-related non-communicable diseases through increased consumption of carbohydrates, fats, (including trans-fats), salt and sugar (Steyn *et al*., 2013).

Implications for attaining Sustainable Development Goals

So far, the interplay of factors responsible for the prevalent food environments in Africa is undergoing rigorous examinations, and much is already understood (Smit, 2018; Holdsworth and Landais, 2019; Osei-kwasi *et al*., 2021). The roles of retail food outlets to consumption patterns have somehow been elucidated. Dietary intake patterns in Africa had long shifted from diets consisting mainly of low energy dense meals that included starchy staples, vegetables, unrefined and minimally processed foods to consumption of highly processed foods, saturated fats and added sugars (Popkin *et al*., 2012). This is because, the existing food environment promotes consumption of a wide range of foods, with consumption of processed and ultra-processed foods becoming more popular (Annan *et al*., 2022; Demmler *et al*., 2017; Khonje and Qaim, 2019; Odunitan-wayas *et al*., 2020). Both processed and ultra-processed foods are high in added fats, salt and sugar. Ultra-processed foods loose most of their natural constituents (including dietary fibre, micronutrients and other health promoting substances) when undergoing multiple processing. They also contain higher amounts of preservatives and include soft drinks, packaged foods that have undergone significant changes in their natural form. Because, ultra-processed foods have high energy content and are low in essential nutrients, consumption of these items over unprocessed foods predisposes consumers to the problems of micronutrient deficiencies and excessive weight gain. Obesity and other diet-related disorders, including diabetes mellitus, cardiovascular diseases, cancers, etc. are common in populations and among individuals consuming more of these items (Chen *et al*., 2020; Gramza-michałowska, 2020). Although, this seems to be blamed on the ever increasing activities of formal food environments, it has also been noted that even the traditional markets now offer varieties of imported and ultra-processed food materials to consumers (Annan *et al*., 2022). Coexistence of both traditional and processed food products in markets within the region points to the extent to which nutrition transition has eaten deep into the society.

There is emphasis on eliminating hunger, while improving food security and general nutrition in SDG two. The present spectrum of nutritional problems in Africa does not portray hunger as a single overwhelming component, rather, there's an emerging coexistence of under-nutrition and over-nutrition (the double burden of malnutrition) brought about by nutrition transition resulting from industrialization and subsequent urbanization in the region (Abrahams *et al*., 2011; Bosu, 2015; Vorster *et al*., 2011). The four pillars of food security - availability, access, utilization and stability also constitute some of the dimensions influencing food environment at the personal level (Downs *et al*., 2020; Turner *et al*., 2017). The concern is on the types of foods that are available for consumption in the region. Availability of low energy, nutrient dense foods will create a healthy food environment desired for ensuring good quality diets for the populace. This is important for the realization of improved nutrition component of the SDG. It has already been revealed that, there are no distinct differences in the types of food materials presented to consumers from the different retail food outlets. Similar food materials are sold at almost all the retail food outlets. The concern on the increased consumption of processed and ultra-processed foods may be justified judging from their compositions. There is need at this point to formulate policies and programmes that can manipulate retail food environments to create a healthier food environment in Africa. The recommendations usually include strategies that boarder on the products, pricing, placement and promotion

(Karpyn *et al*., 2020). Retail outlets can increase stocking and availability of fresh produce; place healthy food items at strategic points to increasing visibility; place discounts on the sales of healthier foods and use nutrition shelf labelling and nutrition education to promote sales of healthy foods (Karpyn *et al*., 2020).

Conclusion and recommendations

Food retail environments in Africa include the traditional wet markets, supermarkets, neighbourhood kiosks and street food vending. Overall, they all provide large number of food items, including fresh produce as well as processed and packaged foods. Notwithstanding, traditional wet markets are most popular for selling unprocessed fresh produce, while supermarkets sell mostly processed and ultra-processed products. The street food vending provide meals that contribute to significant energy and nutrients intakes. Supermarket sales is mostly associated with increased consumption of processed and ultra-processed foods. The prevalent food environment indicated by retail food outlets and their products may pose serious problems of obesity and other chronic diseases in the population because of minimal availability of healthy foods while the system is over flooded with energy dense materials that contribute little or nothing to nutrients intakes. Dietary intake patterns influenced by activities of these food environments violate the drive for achieving food security and improving nutrition as recommended in the SDGs. Manipulating the retail environments through products availability, price, placement and promotions have proven effective in creating a healthy food environments.

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Upgrading Local Breeds Of Farm Animals Through Artificial Insemination Techniques In Tropical Africa: A Review

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Abstract: *The objective of the study is to review artificial insemination (AI) techniques as the fastest vehicle in upgrading and improving livestock performance in tropical Africa. AI is one of the assisted reproduction technologies (ARTs) used in many domestic species including bees and human beings. The application of AI techniques is on the increase in beef cattle, sheep, goats, swine, rabbits, poultry, camels, horses, donkeys, deer, buffalo, and dogs. AI has, also, been successful in conservation breeding of endangered species such as primates, elephants and wild felids. AI allows for widespread use of genetically superior sires that would normally not be available to breeders across tropical Africa. This is because they are too expensive to be purchased and transported. AI allows for faster and increased genetic improvement in farm animals allowing for improved performance. It is the most commonly used assisted reproduction technologies (ART) in livestock, revolutionizing the animal breeding industry during the 20th century. In comparison to medical application, intra-uterine insemination (IUI) is used only occasionally in human fertility treatment. AI is by far the most common method of breeding in intensively kept domestic livestock with dairy cattle having about 80% in Europe and North America, pigs (90%) in Europe and North America and turkeys (100%) in intensive production. The other assisted reproduction technologies (ARTs) in animals are generally confined to specialist applications or for research purposes, since the cost would be prohibitive for normal livestock breeding. It is therefore, recommended that, governmental and non-governmental organizations and wealthy stake-holders in the industry should encourage farmers by supplying semen, reliable methods of estrus detection and training AI personnel to achieve higher conception rates.*

Key-words: AI, Technology, Performance, Livestock, Tropical Africa

CITATION:
Kubkomawa, H. I., Enyenihi, G. E. and Inyang, U. A. (2023). Upgrading Local Breeds of Farm Animals Through Artificial Insemination (Ai) Techniques in Tropical Africa: A Review. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 379- 401

Introduction

Research has shown that, the fastest vehicle in upgrading and improving livestock performance is the combination of the adaptability and hardiness of the *Bos indicus* with the high-performance potentials of the *Bos taurus* through cross-breeding (Richard, 1993; Ngodigha *et al*., 2009; Kubkomawa *et al.,* 2017; Kubkomawa, 2018). To utilize the genetic advantage of the cross-breeding, many decades ago, Nigeria imported several Holstein Friesian (HF) sires for cross-breeding with the local breeds, especially Bunaji (White Fulani) cows. This effort resulted in a considerable improvement in milk production (Oni *et al*., 2001). The results of studies conducted at the

National Animal Production Research Institute (NAPRI), Shika, Nigeria, on the performance of Friesian-Bunaji crossbreds indicated an improvement of about 60% in milk yield of the first cross, and further increase in the level of Friesian blood resulted in an additional gain in yield, but with decreasing magnitude and marked reduction in calving interval and age at first calving (Oni *et al*., 2001). Subsequently, livestock owners and breeders begin to show high interest in the use of exotic breeds or their frozen semen to upgrade the local indigenous dairy cows. The objective of the study is to review AI techniques as the fastest vehicle in upgrading and improving livestock performance in tropical Africa.

Artificial Insemination (AI)

Artificial insemination (AI) is the manual placement of semen in the reproductive tract of the female animal by a method other than natural mating following estrus detection (Kubkomawa *et al.,* 2017; Kubkomawa, 2018) as demonstrated in figures 1 and 2. AI is one of the technologies usually referred to as assisted reproduction technologies (ART), in which, offspring are produced by enabling the meeting of gametes (spermatozoa and oocytes) (DeForest, 1988; Blacksburg, 1988; Kubkomawa *et al.,* 2017; Kubkomawa, 2018). Other techniques encompassed by ART include the following: *in-vitro* fertilization (IVF) where fertilization takes place outside the body; intra-cytoplasmic sperm injection (ICSI) which is a single spermatozoon caught and injected into an oocyte; embryo transfer (ET); gamete intra-fallopian transfer (GIFT) where spermatozoa are injected into the oviduct to be close to the site of fertilization *in-vivo*; and cryo-preservation where spermatozoa or embryos, or occasionally oocytes are cryo-preserved in liquid nitrogen for use at a later stage (Kubkomawa *et al.,* 2017; Kubkomawa, 2018).

Fig. 1: AI Technique in Friesian Cow
(Source: fwi.co.uk)

Fig. 2: AI Technique in Crossbred Cow
(Source: dairymac.com)

Semen Collection

In most domestic animals, semen is collected by means of an artificial vagina, for example, from a bull, ram or stallion, after allowing the male to mount either an estrous female or a phantom (Nafarnda *et al*., 2005; Kubkomawa *et al.,* 2017; Kubkomawa, 2018). The artificial vagina comprises of a lubricated liner which is inserted into an outer jacket, between the two spaces filled with warm water. In non-domestic species, electro-ejaculation is the only possible means of obtaining semen samples. The problem with electro-ejaculation is that, the secretions of the accessory glands may not be present in the usual proportions, which may have a detrimental effect on sperm survival as shown in Figs. 3, 4, 5, 6, 7, 8, 9, 10 and 11.

Fig. 3: Semen Collection in Friesian Bull (Source: www-naweb.iaea.org)

Fig. 4: Semen Collection in Bull (Source: vivo.colostate.edu)

Fig. 5: Semen Collection Using Dummy Cow (Source: researchgate.net)

Fig. 6: Semen Collection Via Artificial Vagina in Bull (Source: rttsafrica.com)

Fig. 7: Semen Collection Using Dummy in Stallion (Source: link.springer.com)

Fig. 8: Semen Collection Via Artificial Vagina in Stallion (Source: westvets.com.au)

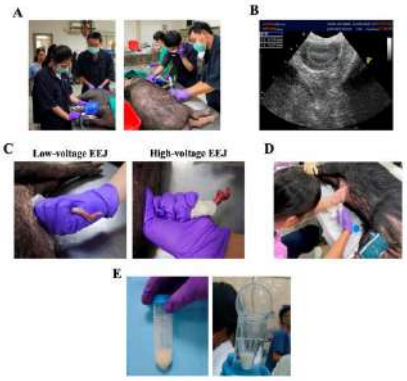

Fig. 9: Semen Collection Using Electro Ejaculator in Camels (Source: mdpi.com)

Fig. 10: Semen Collection Via Withdrawal **(Source: Researchgate.net)**

Semen Constituents

Semen consists of spermatozoa contained in a watery fluid known as seminal plasma that represents the combined secretions of the different accessory glands, such as the seminal vesicles, bulbourethral gland and prostate as can be seen in Figs. 12 and 13. The contributions of these different glands vary between species and environmental conditions. In some species, such as most primates, the semen coagulates immediately after ejaculation and then liquefies over a period of approximately 30 minutes. In most other species, the ejaculate remains liquid, the exception being in camels where the seminal plasma is highly viscous and does not liquefy readily *in vitro.* The addition of enzymes has been suggested as a means of liquefying primate or camel semen. However, all the enzymes tested thus far (collagenase, fibrinolysin, hyaluronidase and trypsin) have been seen to cause acrosomal damage in spermatozoa and are contraindicated if the spermatozoa are to be used for AI (Wani *et al.,* 2007).

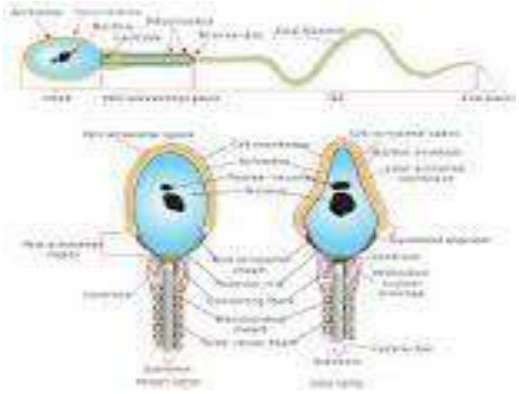

Fig. 12: Semen Constituents (Source: en.wikipedia.org)

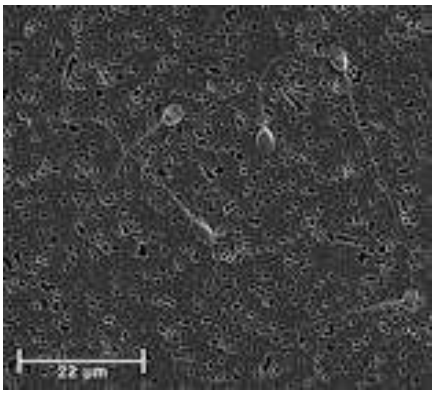

Fig. 13: Semen Constituents (Source: en.wikipedia.org)

Processing of Semen

Although seminal plasma plays an important role in the activation of spermatozoa and in the female reproductive tract, it is dangerous to long-term sperm survival outside the body. Under physiological conditions, sperm cells are activated by seminal plasma at ejaculation and then swim away from the site of semen deposition in the female reproductive tract. It is only during *in-vitro* storage that, sperm cells come in contact with seminal plasma long-term. Thus, it is customary to add a semen extender to the semen, to dilute toxic elements in seminal plasma, to provide nutrients for the spermatozoa during *in-vitro* storage and to buffer their metabolic by-products (Nafarnda *et al*., 2005; Kubkomawa *et al.,* 2017; Kubkomawa, 2018).

Preservation of Semen

Semen is used either immediately after collection (fresh) for example in turkeys, human beings; after storage at a reduced temperature (stored) for example in horses, pigs, dogs; or

after freezing and thawing (cryo-preservation) for example in bulls (Nafarnda *et al*., 2005; Kubkomawa *et al.,* 2017; Kubkomawa, 2018) as shown in Fig. 14.

a. Fresh semen: In contrast to animal species, human semen is not extended prior to processing and is not usually kept for more than a few hours before use. Poultry semen cannot be extended for too long as is done with other species since the sperm cells are adversely affected by increased dilution. Goat semen cannot be kept at 37°C because an enzymatic component of the bulbo-urethral gland secretion hydrolyses milk triglycerides into free fatty acids, which adversely affects the motility and membrane integrity of buck spermatozoa (Pellicer-Rubio and Combarnous, 1998). For liquid preservation, goat semen can be stored at the temperature of 4°C, although viability is retained for only 12-24hours. The extension rate used for stallion varies among countries as 1:2, 1:3 or even 1:4 (v/v) semen extenders.

Fig. 14: Semen Preservation (Source: slideshare.net)

b. Stored semen: Storing of extended semen at reduced temperature helps to extend sperm life by slowing their metabolism as well as by inhibiting bacterial growth. Bacteria grows by utilizing the nutrients in semen extenders, thus competing with spermatozoa for these limited resources, and release metabolic by-products, thus creating an environment that is not conducive to maintaining viable spermatozoa. Nevertheless, cooled stored semen is the common method used for breeding horses and pigs, enabling the semen dose to be transported to different locations for insemination. Stallion semen is normally stored at the temperature approximately 6°C while boar semen is stored between 16 and 18°C. Most boar semen doses are sold and served as cooled doses. In contrast, some stallions produce sperm cells that do not tolerate cooling, rapidly losing progressive motility. In such cases, the only option currently is to use fresh semen doses for AI immediately after semen collection, although a new method of processing, centrifugation through a single layer of colloid, has been shown to solve the problem discussed (Nafarnda *et al*., 2005; Kubkomawa *et al.,* 2017; Kubkomawa, 2018).

c. Cryo-preservation: Semen is most useful for AI if it can be cryo-preserved, since this method of preservation ideally enables the semen to be stored for an unlimited period without loss of quality until needed for AI as shown in figure 15. Since the frozen semen does not deteriorate in viability, it can be examined until the male has been shown to be free from disease at the time of semen collection. However, the sperm cells of various species differ in their ability to survive cryo-preservation. Ruminant sperm cells survive well, whereas poultry sperm cells do not, with less than 2% retaining their viability on thawing (Wishart, 1985). For farm animal breeding, the cost of cryo-preservation and the likelihood of a successful outcome following AI must be considered when deciding whether to use fresh, cooled or frozen sperm doses.

Fig. 15: Cryo-preservation of Semen
(Source: en.wikipedia.org)

Semen Evaluation

When choosing a male for breeding, especially for AI, it is imperative to assess its potential fertility by undertaking clinical and laboratory examinations (Figs. 16 and 17). The *in-vitro* semen evaluation, complementary to the clinical examination, is of high diagnostic value for assessing testicular and epididymal function, and/or the genital tract of the male, allowing elimination of clear-cut cases of infertility or potential sub-fertility (Martin Rillo *et al*., 1996; Rodriguez-Martinez 2003; Saacke, 2008). The semen analysis routinely includes an immediate assessment of volume, appearance such as color, contamination, sperm concentration and motility, as well as later determination of sperm morphology and the presence of foreign cells. Once screened for normality, ejaculates preserved for AI are assessed for sperm concentration and sperm motility.

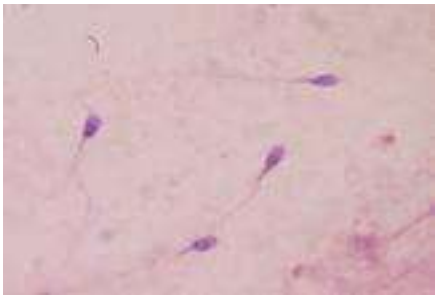

Fig. 16: Semen Analysis
(Source: en.wikipedia.org)

Fig. 17: Semen Evaluation
(Source: slideserve.com)

Sperm Concentration

Accurate and precise determination of sperm concentration in an ejaculate is important for AI programs in order to produce uniform insemination doses containing an adequate number of sperm see Figs. 18 and 19. A certain safety margin is often used by AI stations to ensure that, all insemination doses contain a minimal number of sperm. This, also, implies that, some insemination doses contain an excessive number of sperm and that males of high genetic value are not used efficiently. This safety margin, also, affects the average revenue per ejaculate for the AI station. The concentration of sperm in a straw is dictated by factors that affect semen quality, which are usually based on how the semen survives the freezing and thawing process. Factors include breed of bull, bull to bull variation, and the time of the year the semen is collected. Dairy semen usually freezes better than bulls semen. The average number of sperm cells/straw is 20-40

million. Proportion of sperm that endure the thawing process is between 30 and 80%, which is dependent on the factors listed above. The good AI sires will usually not release semen that has a post-thaw survival rate less than 30%. Average number of live sperm cells/insemination dose is 5-10 million. If the semen is gender selected, the straws will contain approximately 2 million sperm cells. Additionally, only 30% of the sperm survive the freezing and thawing process. Therefore, most companies that sell gender-selected sperm recommend that, it only be used on virgin estrous cycling yearling heifers (Christensen *et al.,* 2005; Kuster 2005; Prathalingam *et al.,* 2006). The use of a spectrophotometer is probably the most frequent method used by AI stations for assessment of sperm concentration (Woelders 1991; Evenson *et al*., 1993). For satisfactory results, periodic calibration of hemocytometers is necessary.

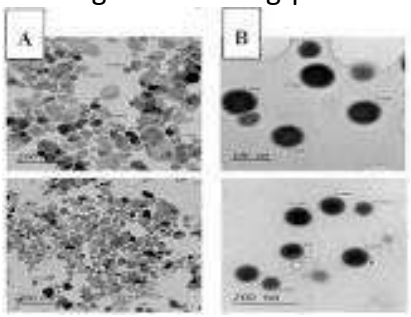

Fig. 18: Semen Concentration (Source: mdpi.com)

Fig. 19: Semen Quality (Source: netdoctor.co.uk)

Sperm Motility

Most frequently, the semen quality of dairy bulls and boars in AI centers is evaluated using sperm concentration and motility in fresh and post-thaw semen for bulls. While studies by Januskauskas *et al*., (1996); Correa *et al*. (1997); Holt *et al.,* (1997); Christensen *et al.* (1999); Tardif *et al*. (1999) have established a correlation between motility and field fertility, and others did not. Good progressive motility of spermatozoa is an indicator of both unimpaired metabolism and intactness of membranes (Johnson *et al.,* 2000) as shown in Figs. 20 and 21. Estimation of motility has fundamental importance in daily quality control of semen. The percentage of motile sperm cells is used to calculate the required degree of dilution and to estimate the number of intact sperm cells per insemination dose. Motility is usually assessed visually via a light microscope. It is inexpensive and quick, but accuracy depends on the subjective estimation by individuals even though, surprisingly, consistent results can be obtained (Woelders, 1991). Objective Computer Assisted Sperm Analysis (CASA) systems have become commercially available, but these systems are not frequently used in commercial AI-centers because of the high investment costs (Verstegen *et al.,* 2002).

Fig. 20: Progressive Sperm

Fig. 21: Slow Tired Sleeping Sperm

Sperm Morphology

Morphological abnormalities of sperm can have a detrimental impact upon fertilization and embryonic development (Walters *et al.,* 2005a; Saacke, 2008). Bulls and boars used for commercial AI are selected to a certain degree on the basis of a low incidence of morphologically abnormal spermatozoa, so that, statistical calculations concerning their correlation with fertility are not very informative (Rodriguez-Martinez *et al*., 1997; Johnson *et al*., 2000), although some evidence for a relationship between sperm morphology and fertility in bulls has been documented (Söderquist *et al.,* 1991; Al-Makhzoomi *et al.,* 2008). A complete morphological examination is recommended when bulls and boars are introduced into the AI station and during subsequent regular routine examinations (Johnson *et al*., 2000; Al-Makhzoomi *et al*., 2008) as can be seen in figures 22 and 23. Principles for determining sample size for morphological assessment of spermatozoa were extensively discussed by Kuster *et al.* (2004).

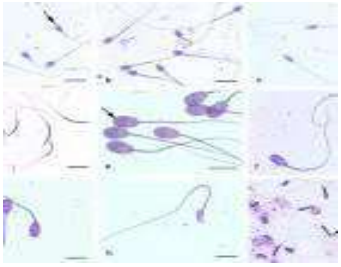

Fig. 22: Sperm Morphology (Source: Researchgate.net)

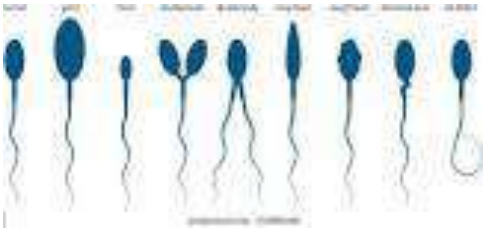

Fig. 23: Sperm Morphology (Source: shutterstock.com)

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The Insemination Dose

The number of sperm in the insemination dose is an important factor affecting the probability that a female will become pregnant after AI, and in litter-bearing animals, also, the litter size (Flowers, 2002) as shown in figure 24. To maximize pregnancy rate, the number of sperm in a dose is intentionally set high, but this management approach tends to obscure differences among males that might impact outcome of breeding when fewer sperm are used (Colenbrander and Kemp, 1990; Woelders, 1991; Amann and Hammerstedt, 1993, 2002; Amann, 2005; Ruiz-Sanchez *et al*., 2006). Certain males achieve maximum fertility after AI with very few motile sperm (1 million for cattle), whereas for other males 20-30x more motile sperm are required to maximize fertility (den Daas, 1992; den Daas *et al.,* 1998; Flowers, 2002). At high sperm numbers per AI dose, individual bulls differ in their maximal NR%.

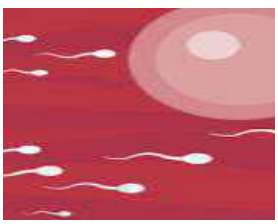

Fig. 24: Sperm Dose (Source: intechopen.com)

Estrus Detection

Research has shown that, the most limiting factor in artificial insemination programs is the proper detection of female animals in estrus. Estrus, or heat, is that period of time that occurs every 18-24 days in sexually mature, non-pregnant female animals (cows or heifers) when they are receptive to mounting activity by males (bulls) or other females (cows). In beef and dairy cattle operations where artificial insemination is the means of breeding the females, the herdsman must recognize and interpret a cow's heat signals. Proper timing of the artificial insemination is necessary to accomplish a high percentage of conception in the cows that are bred artificially. A cow is fertile only when an egg has been released (ovulated) from the ovary. This occurs about 10-14 hours after the period called "standing heat" ends. Because the sperm needs time in the cow's reproductive tract before they are capable of fertilizing the egg, insemination should be made several hours before ovulation. This means that, for the highest fertility, cows or heifers should be inseminated in the latter two-thirds of heat or within a few hours after having gone out of heat. This represents approximately 12-18 hours after the cow first comes in "standing heat (Alphonsus *et al*., 2014; Mai *et al.,* 2014; Kubkomawa *et al.,* 2017; Kubkomawa, 2018).

Signs of Estrus

According to some studies by Alm-Packalén (2009); Alphonsus *et al*., (2014); Mai *et al.,* (2014), the surest sign of estrus is that of a female animal (cow or heifer) that permits other animals to mount her while she remains standing. The most productive means of determining which cows are in "standing heat" is to observe the cattle carefully for about 30 minutes at least twice per day. Many of the cows that have "standing heat" from midnight to 6am can be observed as having "secondary" signs of heat at the time of normal heat-detection on the previous evening as shown in figures 25 and 26. The secondary signs of heat include: (1) a willingness to mount other cows, even though neither cow may be willing to stand for the mount, (2) roughened tail head or mud on the rump, which is evidence that other animals have tried to mount her, (3) restlessness, which may be indicative of a cow about to exhibit heat (cows in pre-heat may bawl more than usual, head-butt, pace the fence, sniff or lick other cattle) as can be seen in figures 27, 28 and 29 and (4) clear stringy mucus discharge which may be hanging from the vulva or smeared on the pin-bones or rump of a cow about to have estrus or one already in estrus. Bloody mucus often appears 2-3 days after estrus has occurred and should be recorded in order to closely watch for heat in 17-21 days.

Fig. 25: Cow Mounting of Others (Source: afimilk.com)

Fig. 26: Doe Mounting of Others (Source: livestocking.net)

Fig. 27: Cow Snuffing of Others
(Source: fwi.co.uk)

Fig. 28: Heifer Snuffing of Others
(Source: youtube.com)

Fig. 29: Cow Restless and Disturbing Others
(Source: kingshay.com)

Induced Ovulation

When AI is performed in species that are normally induced ovulators, such as rabbits, cats and camels, it is necessary to stimulate ovulation (Figs. 30 and 31). The easiest way to achieve this stimulation is to mate the female with a vasectomised male, but this practice is not desirable from the point of view of disease control and because it necessitates having vasectomized males available. The most acceptable alternative is to administer luteinising hormone, usually in the form of human chorionic gonadotrophin. However, the major disadvantage is that, repeated injections of this foreign protein may cause the female to develop antibodies, thus inactivating subsequent doses (Nafarnda *et al*., 2005; Alm-Packalén, 2009; Alphonsus *et al*., 2014; Mai *et al.,* 2014).

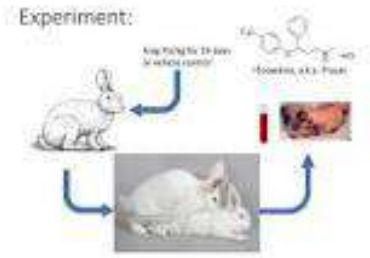

Fig. 30: Induced Ovulation in Rabbits
(Source: experiment.com)

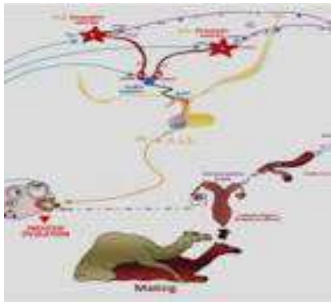

Fig. 31: Induced Ovulation in Camels
(Source: researchgate.net)

Artificially Induced Ovulation

Hormones may be administered to spontaneous ovulators to ensure that ovulation occurs at the correct time relative to AI (Fig. 32). However, since 2006, the use of hormones in food producing animals has been forbidden in the

European Union and local regulations may, also, apply in other parts of the world. Previously most dairy goats in France were inseminated out of the breeding season with deep frozen semen, after induction of estrus and ovulation by hormonal treatments. This protocol provided a kidding rate of approximately 65% (Leboeuf *et al*., 2008). As an alternative to administering artificial hormones, out of season breeding may be induced by altering the photoperiod or by introducing a buck to the herd. This practice is, also, widespread in intensive sheep flocks (Alphonsus *et al*., 2014; Mai *et al.,* 2014).

Fig. 32: Induced Spontaneous Ovulation (Source: sciencedirect.com)

Time of Artificial Insemination

Maximum fertility occurs when cows are bred near the end of "standing heat." Ovulation occurs about 12hours after the end of standing heat as shown in figures 33 and 34. The 12hour lead time allows the sperm cells to go through a process known as capacitation by the time the egg is released. Fertility decreases slightly when cows are bred a few hours on either side of this target, and decreased markedly when breeding occurs more than 12hours away from the end of "standing heat." A guide that has proved to work well for timing AI is called the AM/PM rule (Nafarnda *et al*., 2005; Kubkomawa *et al.,* 2017; Kubkomawa, 2018).

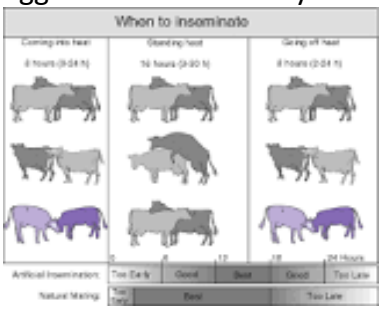

Fig. 33: Time of AI (Source: researchgate.net)

Fig. 34: Time of AI (Source: progreesivedairycanada.com)

Semen Handling

Research has shown that, the information that identifies the semen is labeled 1AN001 while bull's breed (AN), AI center code (1), and bull's ID within AI center (100), Sire's name and registration number from his breed association. Collection date/freeze code tells when the bull's semen was collected, processed, and frozen. Gender of sperm cells packaged is marked as either male or female. If the abbreviation CSS (Certified Semen Services) is on the straw, it means that, the semen was processed under the very strict health guidelines of CSS. Semen that is typically exported is processed according to CSS guidelines (Alphonsus *et al*., 2014; Mai *et al.,* 2014). Frozen bull semen can be stored indefinitely, if it is maintained constantly at very low temperatures. The critical temperature is approximately -112^{o}F. Semen which is exposed

to temperatures warmer than -112°F (even for short time) and then returned to the storage tank may be damaged (Figure 35).

Fig. 35: Proper Handling of Semen
(Source: dairymac.com)

Liquid Nitrogen Tank

Studies have shown that, frozen semen is stored in liquid nitrogen at the temperature of -196°C or in liquid nitrogen vapor -180°C. Therefore, always proceed with caution when using liquid nitrogen. Store the tank in a dry, clean, well-ventilated area, off the floor and out of sunlight. For maintenance purposes, check the liquid nitrogen level frequently and make sure the tank is filled on a regular basis. Semen that has been thawed is no good. Frost or sweat on the tank is indicative of a tank that has developed a leak or has lost its vacuum. Extended and packaged semen can be stored indefinitely in liquid nitrogen (Nafarnda *et al*., 2005; Alm-Packalén, 2009; Alphonsus *et al*., 2014; Mai *et al.,* 2014) as shown in Fig. 36.

Fig. 36: Liquid Nitrogen
(Source: guardian.ng)

The semen storage tank is a large vacuum-sealed metal bottle with an extremely efficient insulation system. Because of the vacuum bottle construction, the temperature can remain at -320° F (liquid nitrogen temperature) as long as at least two inches of liquid nitrogen is present. Technical advances in design and construction have produced storage tanks with a liquid nitrogen holding time of six to nine months. Although semen storage tanks are well constructed, they still are susceptible to damage from mishandling. Avoid excessive movement of the tank.

Thawing of Semen and Loading an AI gun

Pre-warm AI gun and thaw bath at 95°F. Check the breeding records to match the cow with semen she will be inseminated with. Move one straw of semen from the liquid nitrogen tank to the thaw bath as quickly as possible. 0.25 or 0.5ml French straws are thawed for 30 – 40 seconds at 95°F (37°C). Minimize exposure of the straw to sunlight. Don't leave the semen in

the water bath for an extended period of time of more than 15minutes. Don't attempt to refreeze semen if not used. Note: The farther up the neck of the tank the semen is held, the greater the temperature and the increased risk of heat shock and the semen being damaged. Do not hold a canister or cane of semen above the neck of the AI tank any longer than 10seconds. Place straw in a pre-warmed AI gun and place a sterile sheath over the gun and straw as can be seen in figures 37 and 38. Initiate the insemination process by rectally palpating the cervix through the rectum and prepare it to receive the insemination gun. Use a clean paper towel to wipe away any fecal material or mud from the external genitalia of the cow. Place the AI gun into the vagina at a slight angle with the tip of the AI gun pointing upward to avoid the opening of the urethra. Traverse the cervix with the AI gun and deposit the semen right at the tip of the cervical/uterine junction. Deposit the semen slowly (5seconds) (Alm-Packalén, 2009; Alphonsus *et al*., 2014; Mai *et al.,* 2014). The correct thawing recommendation for semen in straws is not the same for all AI organizations. However, almost all organizations now recommend warm-water thawing of straws for 10 to 60seconds. For optimum results, follow the specific recommendations of the semen processor. Here are some thawing tips: Always keep insemination equipment clean, dry and warm; Use a thermometer, do not guess at the temperature. Check the thermometer for accuracy at least every six months with a reference thermometer; Use an insulated water bath designed for thawing semen or a one-pint wide-mouth thermos which is deep enough to immerse the entire straw. Recently, electronic thawing devices which maintain water temperature accurately between 95 and 98^{o}F have been developed as shown in figures 39 and 40.

Fig. 37: Electric Thawing of Semen
(Source: ensufarming.en.made-in-china)

Fig. 38: Manual Thawing of Semen
(Source: dairymac.com)

Fig. 39: Loading of AI Gun
(Source: youtube.com)

Fig. 40: Loading of AI Gun
(Source: m.livestocktool.com)

Handling of Semen during Insemination

After thawing, the semen temperature must be maintained as close to 95^{o}f as possible. Handling thawed semen and preparing the insemination rod should be done in a sheltered, heated area. Proper steps for handling semen include: While the semen is thawing, warm the insemination rod by rubbing it briskly with a paper towel. In cold weather, place the warm rod within clothing so it will be close to the body and

maintain warmth; After the semen is thawed for the required time, dry it thoroughly with a paper towel and protect it from rapid cooling; Adjust the air space in the straw to assure that, no semen is lost when the end of the straw is cut off. Transfer the straw to the rod and cut the tip of the crimp-sealed end of the straw squarely and through the air space. Only sharp scissors or a specially designed straw cutter should be used. Make sure to cut the straw "square" to 41.

Fig. 41: Semen Handling during AI
(Source: nwdistrict.ifas.ufl.edu)

Insemination Process

This involves learning and training your fingers to have sense of feeling especially inside the rectum. The rectum is 10 to 12 inches long and very stretchable. That is important because it is achieve a good seal with the sheath; Wrap the assembled insemination rod in a clean, dry paper towel, and tuck it within your clothing for transportation to the cow. The period of time between removing the semen from the tank and depositing the semen in the cow should not exceed 15 minutes (Alm-Packalén, 2009; Alphonsus *et al*., 2014; Mai *et al.,* 2014) as shown in figure

through the rectum that you will manipulate the cervix as can be seen in figures 42, 43, 44, 45, 46 and 47.

The anus serves as a valve between the rectum and the outside. It is made up of a circular (purse string) muscle located directly under the skin. It surrounds the very end of the rectum. Again, the anus is stretchable hence your hand and arm can easily slip into the rectum. Circular muscle contractions move along the rectal wall toward the outside. (Alm-Packalén, 2009; Alphonsus *et al*., 2014; Mai *et al.,* 2014).

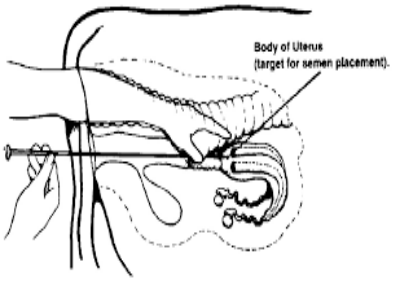

Fig. 42: AI Technique
(Source: extension.okstate.edu)

Fig. 43: AI Technique in Swine
(Source:
wattagnet.com)

Fig. 44: AI Technique in Cows
(Source: M2-Magazine)

Fig. 45: AI Technique in Goats
(Source: ukatheya.com)

Fig. 46: AI Technique in Turkey
(Source: hybridturkeys.com)

Fig. 47: AI Technique in Poultry
(Source: petcraft.com)

The insemination process is quite straightforward. However, since relatively few sperm cells will be used, their placement is critical. The semen should be placed in the body of the uterus just in front of the cervix. You can recognize the proper site by the change in tissue consistency from firm and hard in the cervix to soft and spongy in the uterus. To achieve the highest possible fertility rate, semen should be deposited at the very front end of the cervix. The internal (or front) end of the cervix is often called the anterior cervical. To deposit semen at this location requires the use of a special device called Cassou pipette or AI gun as shown in figures 48, 49, 50, 51, 52 and 53. The recto-vaginal insemination process is used. The inseminator places his hand in the rectum and manipulates the reproductive tract so that, the gun passes through the vagina, then it is manipulated through the cervical rings, and then held at the internal opening of the cervix for semen deposition. In adequately restrained cattle this will take 30 seconds to 2 minutes. At first, however, passing an insemination syringe might not be easy because you might encounter natural obstructions on your way to the target. Next to estrus detection, semen placement error (by the technician) is most likely to affect fertility. (Alm-Packalén, 2009; Alphonsus *et al*., 2014; Mai *et al.,* 2014).

Fig. 48: Digital AI Gun
(Source: agriculture-xprt.com)

Fig. 49: Visual AI Gun
(Source: ebay.com)

Fig. 50: AI Gun for Rabbits
(Source: amazon.com)

Fig.51: AI Gun for Poultry
(Source: iherdsman.com)

Fig. 52: AI Gun for Cows
(Source: dir.indiamart.com)

Fig. 53: AI Gun for Cows
(Source: aliexpress.com)

Sanitary Techniques during Insemination

During insemination, the inseminator is expected to wash his/her hands clean because inseminating cows is an invasion into the delicate uterine environment that is very conducive to bacteria growth. Bacteria on the inseminator's hands could be transferred to the inseminating gun during the loading procedure. If carried into the uterus during insemination, these organisms could thrive and grow rapidly resulting in metritis and infertility (Alm-Packalén, 2009; Alphonsus *et al*., 2014; Mai *et al.,* 2014).

Use of Technicians or Inseminators

Professional technicians are more successful at insemination than inexperienced owners or managers as shown in figures 54, 55 and 56. Inseminators should periodically attend AI courses in order to improve or correct techniques. Selection of a qualified inseminator is an important element in the success of the artificial insemination program. While the insemination process is simple to understand, it does require considerable manipulative skill. Regular practice at inseminating program is required to maintain high conception rates. In many localities, AI studs have trained inseminators who provide insemination service for a reasonable fee. Before producers make a decision whether to hire a trained technician or to train a member of the farm team, they should weigh the considerable cost of a reduced conception rate during the learning process against the fees paid to a trained technician (Alm-Packalén, 2009; Alphonsus *et al*., 2014; Mai *et al.,* 2014).

Fig. 54: Use of Inseminators in Cows
(Source: fwi.co.uk)

Fig. 55: Use of Inseminators in Cows
(Source: dairymac.com)

Fig. 56: Use of Inseminators in Horses (Source: sevg.co.uk)

Successful AI, also, depends on depositing the semen in the female tract at around the time of ovulation (Alm-Packalén, 2009; Alphonsus *et al*., 2014; Mai *et al.,* 2014).

Reproductive Performance in Livestock Following AI

Reproductive ability is the primary source of all benefits derived from livestock, but earlier selective breeding has focused on increased animal production traits (Kubkomawa *et al.,* 2017; Kubkomawa, 2018). The most appropriate assessment of reproductive performance will vary depending on whether emphasis is placed on semen quality, differences among females or comparison of different AI strategies. In semen quality studies, reproductive success is often evaluated using the likelihood of conception after a particular AI (Kubkomawa *et al.,* 2017; Kubkomawa, 2018). For the calving rate, there is a 9month delay for data which is impractical for study purposes. For all types of assessments of reproductive performance, there are some potential systematic errors; including culling and selling of animals that one needs to be aware of when drawing conclusions. The many important aspects in determining differences in male fertility were critically reviewed by Amann and Hammerstedt (2002). It is highly probable that, the use of AI in livestock will continue to increase. AI not only facilitates more effective and efficient livestock production, but can also be coupled to other developing biotechnologies, such as cryo-preservation, selection of robust spermatozoa by single layer centrifugation, and sperm-sex selection (Kubkomawa *et al.,* 2017; Kubkomawa, 2018). Apart from some specialist sheep or goat units focusing on milk production for cheese and intensive meat production, farming of these species tends to be confined to marginal land that is unsuitable for crop production or grazing for dairy cattle. There has been limited selection for production traits. However, there is a resurgence of interest in them now in developed countries because of growing awareness that, small ruminants could represent better utilization of scarce resources than larger ones, such as cattle, while producing less methane and effluent. One potential disadvantage of AI is that, the natural selection mechanisms within the female reproductive tract to select the best spermatozoa for fertilization may be by-passed when AI is utilized.

Conclusion

AI in animal production was originally developed to control the spread of disease, by avoiding the transport of live animals with potential pathogens to other animal units for mating and by avoiding physical contact between individuals. The use of semen extenders containing antibiotics also helped to prevent the transmission of bacterial diseases. The dairy industry's use of AI is a good example of how it can be used for herd improvement, i.e. reproductive efficiency, milk and beef production. AI allows for accelerated progeny testing of sires to determine their genetic potential. It reduces number of bulls needed for natural service and allows the producer to use

larger and heavier bulls on smaller animals without the danger of injury to the females. Progeny derived from the insemination process can be worth more money and allows for introduction of new genetic material via importation of semen from outside the country. No expensive handling, quarantine, and shipping costs of live animals. Frozen semen can be stored and used long after the donor or sire is dead. It enables breeding between animals in different geographic locations, or at different times (even after the male´s death). It, also, allows for the use of semen from an injured sire that is unable to breed naturally. AI allows for more efficient use of estrous synchronization, the process of breeding cows over a 3 to 7 day period compared to 21 days in unsynchronized animals. Breeding can occur in the event of physical, physiological or behavioral abnormalities. AI is a powerful tool when linked to other reproductive biotechnologies such as sperm cryo-preservation and sperm sexing and can be used in conservation of rare breeds or endangered species.

Recommendations

Despite the economic gains of AI, most semen is inexpensive, additional costs associated with AI such as the labor required for estrus detection, the need for an experienced AI technician, and drug cost of estrus synchronization are also capital intensive. Facilities that allow proper restraint of cattle are required so that cattle can be inseminated. Government and all stake-holders should work hand-in-hand to make AI less expensive and accessible to all farmers. This will also encourage the wide adoption of the technology in Nigeria and the tropical Africa at large for better production of animal products and ensure food security

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A Review Of Knowledge On Food Hygiene Among Food Vendors In Nigeria

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Abstract: *The study was carried out to review the sanitary practices and knowledge level of food hygiene among food vendors in Nigeria. The objectives were to review the food vendors' level of knowledge on food hygiene in Nigeria and the personal hygiene/sanitary practices observed by food vendors. . From the reviewed on the food vendors' level of knowledge on food hygiene in Nigeria, three studies reported high level of knowledge while one study reported low level of knowledge of food hygiene. From the reviewed on the personal hygiene and sanitary practices of food vendors in Nigeria, three studies reported moderate level of personal hygiene and sanitary practices amongst the food vendors while two studies reported low level of personal hygiene and safety practice. Furthermore, the aggregate results obtained for the types of personal hygiene observed by food vendors in Nigeria showed that the results obtained for taking baths daily; possession of healthy skin and washing/ironing of clothes, were highly satisfactory. However, the following variables: brushing teeth daily; washing of hands after toilet visit and washing hands with soap and water were moderately satisfactory while cleaning and trimming of fingernails and washing hands before handling foods were unsatisfactory. Moreover, the aggregate types of sanitary practices observed by food vendors in Nigeria showed that food vendors were wearing apron and hand gloves while preparing and serving foods; washing/ rinsing plates used for serving and maintaining a neat kitchen and restaurant and these were moderately satisfactory while covering of hairs during food preparation and serving was unsatisfactory. The review concluded that the level of knowledge of food vendors on food hygiene in Nigeria was high while the level of personal hygiene and sanitary practices was moderate. Amongst other recommendations, the reviewed recommended that food vendors should be motivated to form self-help groups where they can share knowledge and personal experiences on food hygiene as well as invite professionals, such as community health workers, to speak on food safety and hygiene practices.*

Key words: knowledge, food hygiene, food vendors, Nigeria

Citation:
Monday, E. M., Uwem, C. A., Ekanem, U. O. And Uwak, G. (2023). A Review of Knowledge on Food Hygiene Among Food Vendors in Nigeria. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 371-378

Introduction

Food is a vital requirement for life; its purchase, preparation and consumption are necessary for survival. Food is defined as any substance that supplies nutrients and fibre to the body when ingested (Gbigbi *et al.*, 2021). Food availability is not usually as would be expected, which forces the consumers to consume it wherever it is available when needed. The recommended standards for food safety, according to World Health Organization (WHO, 2015) are: prevention of food contamination with

pathogens which can spread from humans, animals and pests; separation of raw food from cooked food to avoid contamination of the cooked food; cooking of foods at the right temperature for the appropriate duration to ensure that pathogens are completely destroyed; storage of foods at the right temperature conditions; using clean water and safe raw materials while cooking food.

Mishandling of foods without regards to hygienic measures can cause pathogenic bacteria and fungi to come in contact with the food items causing diseases such as diarrhea, worm infestation and dysentery, when consumed by humans (Henry *et al.*, 2017; Leslie *et al*., 2021). Therefore, the issue of sanitary quality is very crucial because food safety has become an area of concern as a result of the health risks and the annual death rates from foodborne diseases (Iwu *et al.,* 2017; Trafialek *et al*., 2018; Jike-Wai *et al.,* 2020). Exercising good food hygiene practices is the key in tackling foodborne diseases. Food hygiene involves the process of providing uncontaminated food for consumption through reduction of risk of food poisoning. This can only be achieved with good hygienic practices such as proper washing of dishes/utensils and work surfaces, maintenance of a clean environment and proper waste disposal by food vendors (Calloni, 2013). It is therefore pertinent that food vendors in Nigeria adhere strictly to the food safety guidelines set out by the WHO (2015) to enhance the overall well-being of the Nigeria populace. This study reviewed the sanitary practices and knowledge level of food hygiene among food vendors in Nigeria.

Literature review

Food safety issues are becoming a cause of worry to public health in emerging countries in Africa and Nigeria specifically (Bereda *et al*., 2016). Global estimates by WHO (2019) shows that there were 600 million cases of foodborne diseases and about 420,000 annual death rates from foodborne disease outbreaks caused by pathogenic organisms such as Salmonella, *Vibrio parahaemolyticus*, Proteus, Cereus, Campylobacter, *Escherichia coli* and *Clostridium perfringens* (Ifebajo and Eboh, 2021). In Nigeria, estimates from WHO (2017) shows that more than 200,000 Nigerians die from food poisoning annually. The consequences of food poisoning are also expressed in high cost of medical care, reduced life expectancy, low quality of life and low productivity of labour.

Food poisoning is traceable to poor hygiene by food vendors. Some studies in Nigeria have reported poor food hygiene practices among food vendors (Isara *et al.*, 2017; Iwu *et al.*, 2017; Fasanmi *et al.*, 2018; Okojie and Isah, 2019). A recent study in Nigeria observed that food vendors rarely observed proper personal and food hygiene such as wearing of apron and head covering, covering food items, washing their hands after toilet visit, before or while handling foods (Salihu and Salihu, 2022). Therefore, there is need to carry out a review on the sanitary practices and knowledge level on food hygiene practices among food vendors in Nigeria, in order to unravel their level of adherence to the recommended food hygiene/safety standards of the World Health Organization. This review is an update on existing literature on the various practices by food vendors on food hygiene in Nigeria. .

Food Hygiene

Food hygiene has been defined as the science of producing safe food for consumption without risk of contamination (Calloni, 2013). It involves all the measures necessary to ensure that food is safe and suitable at all the stages of the food chain (Oggiano, 2015). Food hygiene is only achievable when good hygiene practices are duly followed during production, preparation, serving and storage of food items.

Principles of Food Hygiene

The World Health Organization (2012) had set-up five principles of food hygiene aimed at preventing food poisoning as follows:

(a) Prevent food contamination with chemicals
(b) Separate cooked foods from raw ones to prevent contamination of the cooked food
(c) Follow appropriate duration and temperature when cooking food to ensure that pathogens are completely destroyed
(d) Store foods at the appropriate temperature to improve its shelf life
(e) Use only safe water and clean raw materials during food preparation

Food vendors

A food vendor is also anyone who through his/her work, has direct contact with food preparation equipment during any of the phases of the food chain, until the food gets to the final consumers. The phases in which food passes through before getting to the final consumers include manufacture, preparation, processing, packaging, transportation, sales, distribution, storage, supply and services (Imam *et al.*, 2019; Coformacion, 2020).

Plate 1: Stationary food vendor preparing food

Plate 2: Stationary food vendor vending food

The business places of food vendors are train stations, schools, taxi and bus terminals, pavements, hospitals, offices, universities, festival areas, parks, among others (Rathod, 2017; Tadesse *et al.*, 2019). The equipment or utensils utilized by food vendors are cutleries, plates, bowls, chopping boards, to mention but a few.

Responsibilities of a Food Vendor

Alimi and Workneh (2016) has highlighted the responsibilities of food vendors as follows:

(a) Have a good moral and legal responsibility to avoid contamination of food at all cost.
(b) Express a positive attitude towards personal, sanitary, environmental and food hygiene.
(c) Set and maintain a high standard of hygiene at his/her food vending site.
(d) Avoid unhealthy attitude such as nose picking, wearing of long nails and jewelries during food preparation, coughing and sneezing while cooking or serving foods, preparing foods with open cuts and wounds.

Food Vendors' Level of Knowledge of Food Hygiene in Nigeria

The rapidly rising concerns about foodborne diseases have questioned the knowledge level of street food vendors on food hygiene (Addo-Tham *et al.*, 2020). This is because the level of knowledge of street food vendors have a significant impact on their food hygiene practices which will in turn reduce the

concerns/disease burden associated with food contamination (Akinboye and Lois, 2021). Several studies have attempted to assess the knowledge level of food vendors on food hygiene in Nigeria as follows:

Aluh and Aluh (2017) studied the knowledge, attitude and practices of food hygiene among mobile food vendors in a Nigerian rural settlement. Purposive sampling technique was used to select a total of 204 mobile food vendors for the study. The result of the respondents' level of knowledge of food hygiene showed that 81.4% were aware of food hygiene; 59.8% were aware that lack of food hygiene causes diarrhea while 9.3% thought that lack of food hygiene could cause malaria. The percentage of knowledge on food hygiene was 78%. The study recommended that mobile food vendors who deviate from recommended standards of hygiene should be fine appropriately.

Plate 3: Food vendor observing proper food hygiene practice

Plate 4: A well- prepared vended food

Yusuf and Chege (2019) reported the awareness of food hygiene practices and practices among street food vendors in Nassarawa State, Nigeria. A multistage sampling technique was used to select 410 food vendors for the study. The descriptive result of the level of awareness among street food vendors on food hygiene practices showed that only 29.7% of the respondents received trainings on food handling. 63.6% agreed that food vendors who had cuts on their hands should not prepare or serve foods without wearing gloves; 85.5% were aware that cutting boards and knives were capable of cross contaminating foods. Furthermore, 95.1% knew that raw foods should be separated from cooked foods to avoid contamination; 86.8% accepted that proper hand washing can prevent foodborne diseases; 28.8% agreed that reheating cooked foods can contribute to food poisoning; 81.1% felt that there is need to properly choose raw materials for safe food preparation while 96.6% accepted that safe handling of food is an important aspect of food vending. The report recommended more training programmes for food vendors on safe methods of preparing and serving foods.

Akinboye and Lois (2021) assessed the impact of education on the knowledge, attitude and practice of food vendors in Abia State, Nigeria. The study adopted a quasi-experimental study research design which comprised one control group and one experimental group for the selection of 52 food handlers for the study. The knowledge level of the respondents was computed based on a 22 – point rating scale at two levels. A mean score of 0 – 11 points was

considered low knowledge level while a mean score of 12 – 22 points was considered high knowledge level. From the results obtained, the calculated mean level of knowledge in the experimental group before the intervention was 8.33 and increased to 9.12 after the intervention. On the other hand, the calculated mean level of knowledge in the control group before the intervention was 4.71 and increased to 6.15 after the intervention. Although the mean level of knowledge in the post experimental group was highest, the overall level of knowledge of vendors on food hygiene practices in both groups was poor. The report recommended that simple interventions to improve food hygiene knowledge among food handlers should be carried out based on the distinct characteristics of the study population.

Ifebajo and Eboh (2021) assessed the food hygiene practices among vendors in tertiary institutions in Lagos Mainland. Convenience sampling technique was adopted to select 60 food handlers for the study. Descriptive result on the knowledge of food hygiene among food vendors in the study showed that 96.7% of food vendors have heard about foodborne illnesses; 93.3% knew that hand washing minimizes the incidences of foodborne diseases; 88.3% acknowledged that consumption of poorly washed vegetables can be hazardous to health while 60% were aware that cross contamination can occur when vegetables and meat are cut with the same board. Generally, the percentage of food handlers' knowledge of food hygiene was 86.9%. The study recommended that food handlers should be monitored and compelled to adhere to food hygiene practices.

From the studies reviewed, the level of knowledge of food hygiene by food vendors in Nigeria can be summarized with Table 1 below:

Table 1: Summary of empirical literature review of the level of knowledge of food hygiene by food vendors in Nigeria

Author(s)/Year	Location	Sampling Technique	Method of Analysis	Major Finding
Aluh and Aluh (2017)	A Nigerian rural settlement	Purposive sampling	Frequency and Percentages	High level of knowledge
Yusuf and Chege (2019)	Nassarawa State	Multistage sampling	Frequency and Percentages	High level of knowledge
Akinboye and Lois (2021)	Abia State	Quasi-experimental study research design	Means	Low level of knowledge
Ifebayo and Eboh (2021)	Lagos Mainland	Convenience sampling	Frequency and percentages	High level of knowledge

Source: Researcher's compilation

Personal Hygiene and Sanitary Practices of Food Vendors in Nigeria

Good personal hygiene is key to prevention of foodborne diseases (Alimi and Workneh, 2016). Many studies have been carried out on the personal hygiene and sanitary practices of food vendors in Nigeria. Onyia *et al.*, (2019) studied the effect of health education on food hygiene practices and personal hygiene practices of food vendors in public secondary schools in Oshimili South Local Government Area, Delta State, Nigeria. . A total of 54 food vendors were selected for the study. Data were obtained before (pre-test) and after (post –test) the intervention of health educators who assembled the food vendors to create awareness about the need for proper sanitary hygiene and food safety practices. Descriptive result of the personal and sanitary hygiene of the respondents showed that in the pre-test, 4% of the food vendors maintained neat, clean and trimmed fingernails but after the intervention (post-test), the percentage increased to 46%. Moreover, food vendors who covered their hairs during food

preparation and vending increased from 2% in the pre-test study to 8% in the post-test study. It was reported that the mean score of respondents who practiced proper hand washing when selling food increased from 1.71 in the pre-test to 2.12 in the post-test study. Additionally, the mean score of food vendors that protected their food/snacks from flies and dust increased from 2.18 in the pre-test study to 2.54 in the post-test study. The report also showed that 78 and 90% of the respondents did not wear apron and hand gloves respectively. The study concluded that despite the noticeable improvement in personal and sanitary hygiene practices of the food vendors after the intervention of health educators, the hygiene practices of the food vendors was still unsatisfactory. This report recommended that there is dire need for close supervision of food vendors and the vended foods to avoid outbreak of foodborne diseases among school children.

Ifebajo and Eboh (2021) assessed the food hygiene practices among vendors in tertiary institutions in Lagos Mainland. Convenience sampling technique was adopted to select 60 food handlers for the study. The report showed that 20% of the food handlers looked unkempt; 53.3% did not cover their hairs; 31.7% did not trim and clean their nails; 16.7% had unhealthy skin; 75% did not wash their hands frequently; 50% did not wear aprons. The cumulative percentage of food handlers who practiced good personal hygiene was 53.3%. The report recommended that periodic training sessions and orientation programmes should be organized by the Health Departments for food handlers in-order to bring them up-to-date with the global best practices in food handling business.

A similar study on identification of food safety practices among street food vendors in Delta State, Nigeria was conducted by Gbigbi *et al.*, (2021). . Multistage sampling technique was used to randomly select 155 food vendors for the study.. The benchmark mean score was 2.00. Therefore, hygiene variables which scored below 2.00 were considered poorly utilized while those which scored 2.00 and above were considered utilized in the study. From the report , the most utilized hygiene and sanitary practices were: cleanliness of cooking instruments (mean = 2.36), washing of cooking instruments with clean and portable water (mean = 2.59). The poorly utilized hygiene and sanitary practices were: use of personal protective clothing/device (mean = 1.46), personal hygiene (mean = 1.53), wearing of clean clothes (mean = 1.41) and protection of diet from germs/dirt (mean = 1.58). The report recommended that adequate awareness and policies should be put in place to emphasize the need for food vendors to maintain sanitary practices that will promote food safety and suitability.

Salihu and Salihu (2022) reported on the knowledge and practices of food hygiene among food vendors in North Central Geo-political zone of Nigeria. The sample of the study comprised 60 food vendors which were selected through simple random sampling technique. The descriptive report of the personal hygiene practices of the respondents showed that 40% washed their hands before starting food preparation while 60% did not care to wash their hands; 28% washed their hands with soaps or ash and water after visiting the toilet while 72% did not care to wash their hands after toilet visit. 25% cut their finger nails weekly whereas the remaining 75% cut either monthly or whenever they wish. 88% took their baths daily while 12% did not care to take their baths daily. 75% washed and ironed their clothes on a regular basis before wearing while 26% did not care to wash/iron their clothes. 55% brushed their teeth daily with toothpaste while 45% used chewing sticks or charcoal to clean their teeth. Lastly, 40% braided/barbed their hairs regularly while 60% did not braid/barb their hairs on a regular basis. The report recommended that

health education should be made to be a compulsory subject in public schools.

The personal hygiene and sanitary practices of food vendors in Nigeria were assessed with the following variables as shown in the Table below:

Table 2: Summary of empirical literature review of the personal hygiene and safety practices of food vendors in Nigeria

Author(s)/Year	Location	Sampling Technique	Method of Analysis	Major Finding
Onyia Odikpo, Ehiemere, Ihudiebube, Chikaodili, and Ikeh (2019).	Oshimili South, Delta State	Quasi-Experimental design	Frequency and Percentages	Low Personal Hygiene and Sanitary Practice
Ifebayo and Eboh (2021)	Lagos Mainland	Convenience sampling	Frequency and percentages	Moderate Personal Hygiene and Sanitary Practice
Gbigbi, Okonkwo, and Chuks-Okonta, (2021)	Delta State	Multistage sampling	Means	Moderate Personal Hygiene and Sanitary Practice
Salihu and Salihu (2022)	North Central Geopolitical zone	Simple random sampling	Frequency and percentages	Moderate Personal Hygiene and Sanitary Practice

Source: Researcher's compilation

Summary and Conclusion

From the studies reviewed on the food vendors' level of knowledge on food hygiene in Nigeria, three studies reported high level of knowledge while one study reported low level of knowledge of food hygiene. From the studies reviewed on the personal hygiene and sanitary practices of food vendors in Nigeria, three studies reported moderate level of personal hygiene and sanitary practices amongst the food vendors while two studies reported low level of personal hygiene and safety practice. The review concluded that the level of knowledge of food vendors on food hygiene in Nigeria was high while the level of personal hygiene and sanitary practices was moderate.

Recommendations

Among other recommendations, the following recommendations were made:

- Mobile food vendors who deviate from recommended standards of food hygiene should be suspended or with option of fines and sanctions. .
- Food vendors should be motivated and encouraged to form self-help groups where they can share knowledge and personal experiences on food hygiene as well as invite professionals, such as community health workers, to speak on food safety and hygiene practices.

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EFFECT OF INSECURITY ON FOOD SECURITY IN NIGERIA: A PARADIGM SHIFT IN NATIONAL SECURITY ARCHITECTURE FOR SUSTAINABLE DEVELOPMENT

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Abstract: *Agricultural development is the key to economic development for Sub-Saharan Africa including Nigeria. This is because it contributes immensely to the growth and development of such economies as it provides food and raw materials to the non-agricultural sectors of the economy and provides employment opportunities to a vast majority of the unemployed and serves as an avenue by which foreign exchange is earned through export of its products. In recent times, Nigerian economy is besieged by insurgency (Boko Haram Islamic sect and farmers- herders clashes), kidnapping and militancy which have affected all sectors of the economy, with the worse hit on the agricultural sector. However, this paper aimed to broadened the discussions on the scope and extent of insecurity as it affects agricultural production and food security in Nigeria. It also underscores the impediments that insecurity poses to the realization of food security for sustainable development. It highlights that the destructive impact of insecurity are antithetical to farming activities and as such, has led to food shortages with the tendency to worsen the already bad food insecurity situation in Nigeria. It is however recommended among others that government should overhaul the national security architecture from the traditional action – response security system to modern intelligence detectives that employs drones and robotic signals to checkmate and reinforced emerging insecurity threat for national cohesion and development.*

Keywords: Insecurity, Food Security, National Security and Sustainable Development

CITATION:
Iwatt, E. B.; Job, I. A. and Udoh, F. E. (2023). Effect of Insecurity on Food Security in Nigeria: A Paradigm Shift in National Security Architecture for Sustainable Development. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 360-370

Introduction

Nigeria is a country with estimated population of about 170,123,740 people as at 2006 census report (NPC 2006). It has diverse people and culture with over 250 ethnic groups. Geographically, the country is divided into four (4) agro-ecological zones which influence the type of farming system and agricultural production of the people. The rainforest belt in the South, enlarged Guinea savannah across the middle belt, the Sudan savannah in the North West and a mixture of Sudan and Sahel savannah along the North Eastern flank of the country. Agriculture is the main occupation and the means of livelihood of the inhabitants of the country. However, it has 91 million hectares of arable land area. Agriculture is the most important sector of the Nigerian economy employing over 70 percent of the labour force. According to 2008 statistics, agricultural sector

accounted for between 45 to 55 percent of the GDP that year. Nigeria ranks 25 worldwide and rank one in Africa for farm output as about 80 percent of its production comes from subsistence farms. Nigerian Agriculture is dominated by crop production which is estimated to have produced 85 percent of the agricultural output, while the remaining 15 percent comprises livestock, fisheries and poultry.

In recent time, insecurity has been a major challenge to the nation with farmers and agricultural production seriously affected. This challenge has posed significant level of threats to the safety of life, property and corporate existence of the nation. The security of a nation entails the safety of all component units of the nation including all the institutions such as worship centres, police, embassies, government agencies and offices, educational institutions, farms and other business enterprises. Section 13 (2) (b) of the 1999 constitution, saddles the government with the primary responsibility to provide security and welfare for the citizens for the protection of lives and properties (FRN. 1999, Adesula, 2019). However, this paper clearly highlighted that Nigeria is not at war in the real sense of the word, but the carnage resulting from various form of insecurity qualifies it to be regarded as conflict-ridden and at war, Conventionally, the threshold require to classify an armed conflict as a civil war is to record 1,000 battled deaths (Dupuy and Rustad 2018).

Nigeria has consistently recorded deaths in excess of 1,000 from various conflicts unleashed by various groups across the country in recent years. Both the Nigeria Security Trackers and the Armed Conflict Location and Event Data Projects (ACLED) estimated the total number of deaths associated with Boko Haram terrorist group between June 2011 and June 2018 at 34,261 and 37,530 people (Campell and Harwood, 2018). In 2018 alone, there were about 10,665 fatalities from various types of violence in Nigeria with the highest source of violence deaths resulting from criminal activities which recorded 3,425 deaths in 1,191 incidents (Ogundiya and Amzat, 2006). Food security in Nigeria requires actions in multiple dimensions, including improvement in governance structure and responsible investment in agriculture and rural infrastructure. It also involved improvement in health and education of farmers and rural households and the strengthening of social protection mechanisms against risk and insecurity. However; concerted efforts is required to translate government agricultural policies into programmes for the achievement of food security in Nigeria.

Thus, this paper seeks to examine the effect of insecurity on food security in Nigeria and to highlight the need for a paradigm shift in the national security architecture to contain insecurity challenges for sustainable development. It also aimed at providing a baseline information on the effects of incessant attack on farmers and farming households on agricultural production and rural welfare in Nigeria.

Conceptual Clarification

Insecurity

Insecurity is a situation in which there is no peace and there is threat to lives and properties. These threats may include armed robbery, kidnapping, Boko-haram insurgency, rape, suicide bombing, ethnic and religious crises. The term insecurity is used to describe a situation whereby there is feeling of inadequacy in the protection of lives and properties of individuals (King, 2016). Most administration cannot stand the test of time where there is absence of peace and security. Nigeria is witnessing a high rate of insecurity to lives and properties. When there is insecurity in the country, a country finds it difficult to promote businesses to feed the populace. Administrators find it difficult to practice their profession to improve good

governance. This goes a long way to promotes unemployment and poverty

Insecurity is cause as a result of structural entrenched crisis of development that creates environment for the emergence of poverty, unemployment and inequality in the country (Adesula, 2019). Insecurity can lead to the following critical incidents: bomb blasts, cult killings, fire explosion with injuries or significant damage, infection diseases, missing students, quest for wealth, carefree travels by teachers, rechanneling school fees, assault to students, mental health crisis, extortion by teachers, drug/alcohol, sexual assault, death of a student (on or off campus), significant injury on a student, mass exodus of teachers, less preference for teacher education, fewer female teachers in primary, Secondary and colleges of education, few females and males in some programmes, program establishment without recourse to parent body and non or accredited programmes, increase in school fees, attempted suicide, policy revision and policy reversal (Fadare *et al*., 2019).

Food Security

Food security is the provision of food in such a quality and quantity to enhance self- sufficiency in food consumption. It is a sustainable access, availability and affordability of quality food for all citizens for consumption and export. It is the accessibility of all people, at all times, to enough food for an active and healthy life (Reutlinger 1987). Food security has two aspects; ensuring that adequate food supplies are available, and that households whose members suffers from under nutrition have the ability to acquire food, either by producing it themselves or by being able to purchase it. Food insecurity on the other hand refers to deficit or shortfall in actual per capita calorie intake below the minimum per calorie intake recommended by FAO and WHO for maintaining the human body – 2450kcal/day (Rosen and Shapouri 1994). Most countries with widespread food security problems are assessed based on three indicators; low average levels of calorie consumption, large fluctuations and low level of food consumption and large number of absolute poor people. Food insecurity often results in human suffering, substantial productivity losses and a misallocation of scarce resources due to diminished work performance, low cognitive ability and ineffective income earning decisions (Braun et al, 1992). From the foregoing Nigeria is considered a food insecured nation. One of the common characteristics of food insecurity in Nigeria is insecurity which causes threat to farmers and limited access to farmland for the fear of being kidnapped or harassed.

The role of agriculture in the provision of food, raw materials for industries and employment opportunities for Nigeria's teeming population has made this sector very crucial in the country's economic development. Incidentally insecurity has brought untold hardship and economic downturn to the farmers who are the key players in the sector despite the fact that food is one of the basic necessities of life for with members of the insurgence inclusive. In Nigeria, agricultural sector is affected by two major forms of insecurity, namely the farmers–herders clashes and the kidnapping of farmers for rape, torture, and demand for payment of ransom. The effect of this is that farmer do not feel free to carryout their business of planting and rearing for increase in output.

National Security

Security is one of the basic needs of people no matter the age bracket or status or territorial environment. In Maslows hierarchy of needs, security and safety is ranked second to physiological needs of food, clothings and shelter. People desire to have peace and to be in control of their lives and assets (Ogehi 2021, in Charles and Beetseh, 2022). It is the statutory responsibility of the state to provide security for lives and properties of all citizens for sustainable

economic and socio-cultural development. National security therefore require the political will on the part of government to tackle security challenges. This political-will thus, influences the decision, commitment and priority of government on security matters. Nigeria is currently grappling with the problems of underdevelopment, killings, kidnappings, murder, poverty, inequality, hunger, banditry and ethnic conflicts. For Instance, the activities of Boko Haram, Fulani herdsmen and kidnapping gangs are getting out of hands. In September 5, 2021 in Adamawa state, more than 50 schools were closed down. Niger State Traditional Rulers were kidnapped. Katsina State lawmaker's wife was attacked followed by other road killings, the Abuja- Kaduna train attacked of 2022 and the Edo State train attack of January 2023 and the subsequent abduction and torturre of commuters, the temporary closure of all schools in Nassarawa State in 2022 are cases of insecurity against the state. These among others have led to the setting up of Joint Task Force (JTF) and patrol teams along major highways for the protection of lives of citizens in the country (Silverbird T.V Sept. 5 2022). National insecurity has much implications on food production and food security. In Benue state for instance, over ten (10) farming communities were invaded between the year 2020 and 2022 and farmers driven out of their homes to Internally Displaced People (IDP) camps. Potential farmers were also displaced in Adamawa State, Borno State, Yobe State, Kaduna State, Zamfara State etc. over 10 million people were internally displaced in Nigeria between 2018 and 2022 all of whom are farmers (Imhonopi, and Urim, 2012). When the farming population who are supposed to be in farms in their respective communities are forcefully driven to the IDP camps, the national agricultural output is bound to dropped; this is part of Nigeria experience in national insecurity.

Sustainable Development

Sustainable development is the kind of development that seeks to achieve the national economy goals of reducing the level of unemployment, reduction of poverty and inequality through the use of national resources without compromising the need of the future generation in the use of the same natural resource (Dupuy and Rustad 2018). It brings to light how the present generation should act towards nature in the reservation of natural resources for the future generation. Sustainability aimed at doing justice in the domain of individual-nature-relationship in view of the long term future needs, However sustainability involves two dimensions namely; economic sustainability and environmental sustainability.

The concept of sustainable development was first discussed at international level after the publication of the report "Our Common Future" in 1987 by the World commission on Environment and development of the United Nations. Sustainable development put into consideration the present condition of the people without compromising the need for resource for the future generations. Sustainable national development is the process of improving the range of opportunities that will enable individuals and communities to achieve their aspirations and full potential over a sustained period of time while maintaining the resilience of economic, social and environmental systems, it helps to satisfy the basic needs of the citizens in the provision of employment opportunities, increase in income for the overall promotion of human welfare (Fadare *et al*., 2019)

Sustainable development is the development that helps to meet the need of the present without compromising the resources to meet the need of the future generation. King (2016) defined sustainable development as "the development that meets the needs of the

present without compromising the ability of the future generations to meet their own needs." In another definition, King, (2016) quoting Munasinghe (2004), sustainable development is perceived as a process of improving the range of opportunities that will enable individual humans and communities to achieve their aspirations and full potential over a sustained period of time while maintaining the resilience of economic, social and environmental systems. Ogehi 2021) identified some objectives which sustainable national development is expected to realize: increase capital income and employment, promoting human welfare satisfying basic needs: protecting the environment. Considering the path of future generation, achieving equity between rich and poor and participation on broad basis in development and decision making is important. From the above definitions, there is common phenomenon which they all shared: that is prioritizing the development of the present generation without compromising the future generation with language education.

Terrorism and Banditry

Terrorism is seen as a socio-political upset that as grown to the disadvantage of the state security system and the global economy (Ogundiya and Amsat 2006). The manifestation of Boko Haram activities in the serous form of bombs/gun attacks on state security architecture (the police stations, army barracks, prisons) and other organisations such as the church, schools and public institutions and prominent personalities and abduction of over 250 young school girls from Chibok, Borno State in Nigeria is a clear manifestation of organise crime against the state. The killing of men, women and children in Taraba State, Enugu State, Benue State, etc. by Fulani herdsmen, the arm banditry in Zamfara State, Plateau and other part of the country especially in the northeast are cases of sophisticated attach/ insurgency against the state. The abduction of school children in Kankara community in Katsina State and in Niger state are cases of deplorable security situation in the country. These deplorable security situations have threatened most farming communities which are the main trust of agricultural production.

A Brief History of Insecurity/Insurgency in Nigeria

Nigeria in recent times has witnessed an unprecedented level of insecurity. This has made national security threat to be a major issue for the government and has prompted huge allocation of the national budget to tackle insecurity (Achumba et al 2018). No region has been spared the vicious scourge of conflicts though their prevalence and intensity have not been the same across the length and breadth of the nation. Thus, fingers are swift in pointing accusingly to colonial legacies and continual interplay of external and internal imperialist forces that fan the ember of violence for self-aggrandizement. The present situation is further intensified by elements of globalization, proliferation of arms and light weapons, corruption executive lawlessness and leadership ineptitude (Chinwokwu, 2022)

Modern form of insecurity has been more complicated and is observed to be rooted to the activities of the alien Islamic sect, "The Boko Haram"(which literally mean western education is forbidden). It is a religious extremist group avowedly committed to the islamization of Nigeria and imposition of sharia law by means of force. In a media statement dated Tuesday, August 9, 2011 and signed by one Mallam Sani Umaru, as Acting Leader of Boko Haram, the sect reiterated it demands for the full implementation of sharia law and the overthrown of western civilization. In what could only be described as the declaration of war they proceeded to make the following demands as quoted below;

i. *"That we have started a Jihad in Nigeria which no force on earth can stop. The aim is to Islamize Nigeria and ensure rule by a*

purported Muslim majority in the country. We will teach Nigeria lesson, a very bitter one.

ii. *That from the month of August, we shall carryout series of bombing in the Southern and Northern Nigerian cities beginning with Lagos, Ibadan, Enugu and Port Harcourt. The bombing will not stop until sharia is enforced and western civilization is wiped out of Nigeria. We will not stop until these evil cities are turned to ashes.*
iii. *That we shall make the country ungovernable, kill and eliminate irresponsible political leaders of all leaning, hunt and gun down those who oppose the rule of sharia in Nigeria and ensure that the infidel does not go unpunished.*
iv. *We promise the west and southern Nigeria, a horrible pastime. We shall focus on those areas which is the devil's empire and has been the one encouraging and sponsoring western civilization in the shores of Nigeria.*
v. *We call on all Northerners in the Islamic state to quit the followership of the wicked political parties leading the country, the corrupt, irresponsible, criminal, murderous political leadership, and join the struggle for Islamic society that will be corruption free, Sodom free, where security will be guaranteed and there will be peace under Islam.*
vi. *That very soon, we shall stir Lagos, the evil city and Nigeria's South –West and South-East in a way no one has ever done before. Al Hakubrah!*
vii. *It's either you are for us or against us. Mallam Sani Umaru (Acting Leader- Boko Haram")* (Vanguard Newspapers, August 9, 2011)

From the foregoing, it is clearly seen that the modern form of insecurity in Nigeria is alien and not indigenous to the Nigerian culture and tradition and that it is politically and religiously motivated with the aim to achieve political divide along religious line. However, the activities of the sect has not been obvious in Akwa Ibom, but the threat of such level of insecurity has motivated and exacerbated some forms and pockets of insecurity in all neighbouring states across the country. It is also important to state that farmer are the primary target of the sect in order to hold the government to ransom and to as well project the nation as a failed state in the area of protection of lives and properties of the citizens,

Current Dimension of Insecurity and its Effect on Food security

Insecurity is the absence of protection or safety Achumba et al (2018). It is a state of fear, vulnerability to attacks, dangers, emotional and psychological trauma, as well as dead. Insecurity is a product of insurgency. Insurgency is explained as a political movement aimed at realizing a specific political goal which is generally to overthrow a government through subversive means and armed conflict for the control of power, sharing of power and resources of a nation. Prior to 2014, insecurity in Nigeria was limited to armed robbery, violence among communities emanating from land disputes, political riot and other forms of unwholesome behaviours. Farmers- herders clashes was also apparent in some farming communities; the magnitude of this was not so alarming as the local authorities in collaboration with the Nigerian police were able to contain the excesses and to fore-stole peace and orderliness among the worrying groups whenever it occurs.

In recent time, insurgency in northern states especially in the north- east and in other regions has caused many farmers to abandon their farms. This is as a result of fear of attacks especially by marauding Boko Haram insurgents, clashes between the herdsmen and the farmers, communal conflicts and other forms of conflicts. The farmers are no longer able to produce sufficient food quantities to meet the demand from other parts of Nigeria. Most of the youths

who use to support agriculture in the rural areas have been killed or moved away from their farms. This has reduced the labour needed in the agricultural sector of the region of Nigeria. Others, for their own safety have escaped to the neighbouring countries as refugees which becomes an endemic problem (Chinwokwu, 2022).

Table 1.0 below provides the information on food import as a percentage of total import and Agric GDP as a Percentage of Total GDP in Nigeria for the period 2000 to 2021

Table 1: Showing the Percentage of Food Import in Total Import and Agric. GDP as a Percentage of Total GDP as Indicators of Food Insecurity in Nigeria for the period 2000 to 2021

Year	Total GDP (in N Billion)	Agric. GDP (in N Billion)	Total Import (in N Billion)	Food Import (in N Billion)	% of Food Import in Total Import	% of Agric GDP in Total GDP
2000	6,897.48	4840.97	985,022.40	113,630.50	11.53	70.18
2001	8,134.14	5024.54	1,358,180.30	160,209.10	11.79	61.77
2002	11,332.25	7817.08	1,512,695.33	144,297.64	9.53	68.98
2003	13,301.56	8364.83	2,080,235.27	201,648.30	9.69	62.88
2004	17,321.30	8888.57	1,987,045.27	178747.44	8.99	51.31
2005	22,269.98	9516.79	2,800,856.33	195259.09	6.97	42.73
2006	28,662.47	10,222.47	3,108,519.32	214487.68	6.89	35.66
2007	32,995.38	10958.47	3,911952.63	269924.54	6.89	33.21
2008	39,157.88	11645.37	5,189802.62	311388.16	6.00	29.73
2009	44,285.56	12330.33	5,102534.38	446896.65	8.75	27.84
2010	54,612.26	13048.89	7,614656.23	693255.37	9.10	23.89
2011	62,980.40	13429.38	10,229425.71	2885437.15	28.20	21.32
2012	71,713.94	14329.70	9,426,139.81	1294035.18	13.72	19.98
2013	80,092.56	14,750.52	10,476254.79	2,752,915.19	26.27	18.41
2014	89,043.62	15380.39	11253864.75	2,953,893.12	26.24	17.27
2015	94,144.96	15952.22	12,539,542.83	3016538.61	24.05	16.94
2016	101,489.49	16607.34	14,874,342.87	6,753,327.04	45.40	16.36
2017	113,711.63	17179.50	17,974240.52	8643218.86	48.08	15.10
2018	127,736.83	17544.15	21,984342.74	11,754326.90	53.46	13.73
2019	144,210.49	17958.38	25,865,431.21	12,873438.53	49.77	12.45
2020	149,316.86	18348.18	28,986,432.13	15,632,873.84	53.93	12.28
2021	156,639.72	18738.41	NA	NA	11.53	11.96

.Source: Central Bank of Nigeria Statistical Bulletin Various issues

From the Table 1, it could be observed that there has been a steady decline in the share of agriculture in the total GDP for the period 2000 to 2021 falling from 70.18 percent in the year 2000 to a marginal value of 11.96 percent in the year 2021 while the share of food import in the total import was fluctuating between the year 2000 and 2009 and thereafter experience a steady rise from the year 2010 to 2021. This trend in food import may be attributed to the effect of insecurity which has had a deadly told on the agricultural sub-sector of the economy of which the Nigerian–state cannot put an end to it.

Causes of Insecurity

There are several indices that can cause insecurity. Some of the causes of insecurity are:

i. High level of moral decadence,
ii. Religious fanaticism,
iii. Lack of spirit of Patriotism
iv. High level of Poverty
v. Negative effect of foreign culture and poor parental upbringing.
vi. Youth unemployment

vii. Poor government policies
viii. Poor leadership
ix. Weak judiciary system
x. Political structural arrangement
xi. Diversity of culture, tradition and religion
xii. Lack of trust and intolerance
xiii. Fear of domination/marginalization
xiv. Political ambition by politicians
xv. Illiteracy

Examples of Insecurity

- Human and drug trafficking
- Porous borders
- proliferation of arms and ammunitions
- Ethic-religious conflict
- Political based violence
- Periodic outbreak of deadly diseases

Challenges of Insecurity

The challenges of insecurity in Nigeria are at an alarming stage. Some of the challenges include:

- Bombing
- Suicide bomb attacks
- Sporadic shootings of unarmed and innocent citizens
- Burning of police stations
- Churches
- Kidnapping
- Rape
- Armed robbery
- Political crisis
- Murder / unwarranted killings
- Destruction of oil facilities by Niger Delta youth alongside the Fulani Herdsmen.

Nigeria has been included among the terrorist countries of the world. Infact, it ranks the third position as reported by 2020 global terrorism index.

National Security Architecture and the Challenges of Insecurity in Nigeria

In Nigeria, the agencies saddled with the responsibility to tackle insecurity are the Nigerian Army, the Police Force and the National Security and Civil Defense Corp. The Nigerian Custom service and the Nigerian Immigration Services are specialized paramilitary formations with National Security as their secondary mandate. The orthodox security operations in Nigeria have been to respond to cases of bridge to security as they occur. The officers were combatant ready to react to issues of insecurity by what we called "Issues- Response –Model" in recent times, this model is bedeviled by some many short comings which make the citizens to be unsafe and unsecured. Some of the shortcomings are traceable to the following:

i. Lapses in intelligence gathering and proper utilisation of same.
ii. Poor governance which tends to prolong/widen the response and intervention gap between the period of occurrence of event and the response time.
iii. Unwillingness of the public to share viable information with the security agencies(arising from fear of danger when such information are not properly handled)
iv. Lack of citizen's involvement in state security management and their reluctance in volunteering security information to law enforcement agencies remain part of the lapses in critical security elements application
v. Red-tapism on the part of the security administration which affect effective/prompt decision making
vi. Lack of proper employment and accurate designation of tasks by the security administrators
vii. The inability of the government to rise promptly to intelligence information in their disposal to combat insecurity.

Security challenges in Nigeria manifest in several dimensions and people have always been disturbed by series-of crimes that they are not familiar with which sprang up daily in the country. Dupuy and Rustad (2018) describe that

security lapses and challenges manifest on daily basis in forms of youth restiveness, terrorism, and insurgent attacks, hired political assassination, murder, cult-related activities, mass protests, and so forth. Many of the aforementioned crimes and many others not mentioned are alien to Nigeria society. Specifically the crime of terrorism that has devastated the country, mostly the north-eastern part of the country is one of the contemporary security challenges which as threatened the national security. Several thousands of people have lost their lives and property to Boko Haram insurgency over the years. The perennial attacks on natural resources in the Niger Delta by Niger Delta militants which has now taken the form of kidnapping for ransom in which several unemployed youths now engaged in all parts of the country is another security challenge that the security sector is grappling to unravel.

Efforts at Achieving Food Security in Nigeria

Successive governments since independence have made efforts to achieve food security in the country. In the year 1960s, agriculture was the main stay of the Nigerian economy. Nigeria depended on agriculture to provide infrastructure and services until the collapse of the first republic, and the military take-over of the government in 1966. The broad goal of agriculture within this period was rapid attainment of food sufficiency for consumption and export. Within the decade of the 1970s, the government introduced the National Food Production Programme, and the Nigeria Agriculture and Cooperative Bank which was established to fund agriculture and assist farmers. This was followed by the Operation Feed the Nation in 1976. The programme was fashioned to revolutionize the agricultural sector of the economy which was derailing from its normal contribution to the economy. For instance, between 1965 and 1970 te percentage share of agriculture in total GDP was 54.8. This dropped to 38.6 percent between 1971 and 1975 and reduced further to 21.1 percent in 1976 to 1980

In addition, eleven River Basin Development Authorities (RBDA) were established to facilitate irrigation agriculture as an attempt to expand farmlands. Also farm settlements were also established for cash and food crop production to reduce food importation. Government efforts between 1981 and 1985yielded some positive results, evidenced by the contribution of agriculture to GDP which rose from 21.1 percent in 1981 to 35.4 percent in 1985. This was the outcome of the implementation of Green Revolution Programme of Alh. Shehu Shagari Administration which complemented the RBDA programme. The Military Administration of General Badamosi Babangida in 1986 introduced the Rural Infrastructural Development Programme and established the Directorate of Food, Road and Rural Infrastructure (DFRRI). The primary objective of the programme was to open up rural areas for effective agricultural activities and to boost foo production. The effort raised the contribution od agriculture to GDP to 39.9 percent, while food production also increased considerably. However, a down turn trend was observed from 1991. This has persisted ever since. Food importation has rater been on the increase with sustained decline in domestic production. This was the period of "essential commodity" and the beginning of massive corruption which permeated various sectors of the economy. This was the situation until 1999 when a democratic government was sworn in. during this period, the Fadama Development Project which was introduced in 1992 did not make sufficient impact. The democratic government in 1999 headed by President Olusegun Obasanjo initiated some policies and programmes which involved; recognizing, restructuring, privatizing institutions and agencies of government and encouraging partnership to make impact (Nigerian

Agricultural Cooperatives and Rural Development Bank, NACRDB was established in the year (2000); National Agricultural Development Fund (NADF) in 2002; National Special Programme on Food Security NSPFS in 2002; Commodity Marketing and Developing Company (CMDC) in 2003). All these have had some positive impact on agricultural production and consequent improvement in the contribution of agriculture to aggregate gross domestic product GDP.

On the whole, despite all the effort of government to enhance food security, insecurity has been the greatest monster that has bedeviled the agricultural sector in recent times. In Nigeria, three (3) forms of insecurity are apparent as it relates to agricultural production. These are the farmers- herders clashes, kidnapping and the outright terrorizing of the farm by the Boko Haram insurgence.

Prospects/ The Way Forward

To tackle insecurity, the unitary security structure of Nigeria federal state should be looked into with the view to relinquishing some power to the component states and the local government authorities who are quasi-independent federating units to also help to provide security to their localities to overcome the national security challenges. Efforts should be made to trace those who finance and sponsored insecurities in Nigeria. We should also learn to report criminal syndicates in our neighbourhood to law enforcement agencies.

Conclusion

State security is significant and best understood in the context of evolution of the country's history, politics and ideologies. Every nation reforms or restructures its security formations, institutions and strategies in response to established attacks or as a consequence of informed analysis of an anticipated threat to national security or both. The paper clearly highlighted that Nigeria is not at war in the real sense of the word, but the carnage resulting from various form of insecurity qualifies it to be regarded as conflict-ridden and at war, Conventionally, the threshold require to classify an armed conflict as a civil war is to record 1,000 battled deaths (Dupuy and Rustad 2018). Nigeria has consistently recorded deaths in excess of 1,000 from various conflicts unleshed by various groups across the country in recent years with agricultural sector at the receiving end.

Food security in Nigeria requires actions in multiple dimensions, including improvement in governance structure and responsible investment in agriculture and rural infrastructure. It also involved improvement in health and education of farmers and rural households and the strengthening of social protection mechanisms against risk and insecurity. However; concerted efforts is required to translate government agricultural policies into programmes for the achievement of food security in Nigeria.

Recommendations

Based on the findings of the study, the following recommendations are made;

1. Government should take legal and justifiable action to ensure that the ills caused by Boko Haram to the agricultural sector are addressed and farmers encouraged with better incentives to go back to farm.
2. The response mechanism of the state to security issues should be enhanced to checkmate some state level security challenges.
3. There should be a change in the national security architecture from the traditional responses approach to crime prevention strategies which involves the use of computer and robotic devices,

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Mitigating The Effects Of Flood Hazards On Agriculture Using Remote Sensing And Gis

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Abstract :*In recent times, flood has become one of the most common and destructive natural disasters on earth. Its damning effect has brought about huge losses to lives, properties, livelihood systems, infrastructure and public utilities. In Nigeria, the effect of flood has hit an alarming height due to heavy rainfalls, climate change, indiscriminate construction on natural flood plains and storm water paths and poor drainage systems in many residential areas. This has been worst felt in the agricultural sector which is the source for food production, employment, and livelihood in the country. This adverse effect caused by floods has led to hardship and food instability. Flood studies have been greatly improved with geospatial technology mainly in three phases of floods; before floods (preparedness phase), during floods (monitoring phase) and after floods (damage assessment and mitigation phase). This method is robust enough to develop flood hazard zoning maps and map shelter sites for flood management. This paper describes the application of Remote Sensing and Geographical Information Systems in mitigating flood hazards and its impact on agriculture.*

Keywords: Mitigating, Floods, Agriculture, Remote Sensing, GIS
Citation:

Obot, O. I., Udom, G. N., Daniel, K. S. and Akpan, U. F. (2023). Mitigating the Effects of Flood Hazards on Agriculture Using Remote Sensing and GIS. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 350-359

Introduction

Flood refers to the overflow or discharge of a large body of water over a terrain that is usually not submerged (Daniel and Udo, 2019). It is an extreme weather occurrence that is naturally induced by several factors which include: increase in the average global temperature which causes heavy rain, ocean thermal expansion, glacier melt among others. These factors together generate a rise in sea level, which causes water to inundate coastal areas. Flooding submerges plants and animals, including people, buildings, and infrastructure (Ujene and Oguike, 2020). However, flooding is a widespread natural danger that has harmed people, caused loss of properties, and contributed to the extinction of numerous species of living organisms. In actuality, flooding poses a threat to the environment's quality and given the problems associated with flooding, it is regarded as a factor that is used in defining the environmental quality of residential neighbourhoods.

While Nigeria typically experiences seasonal flooding, the 2022 Nigeria floods were the worst in the country since the 2012 floods. The floods affected many parts of the country. According to Nwiyii, *et al.* (2022), the floods had displaced over 1.4 million people, killed over 603 people, and injured more than 2,400 persons. About 82,035 houses had been damaged, and 332,327 hectares of land had also been affected. The Nigerian government blamed the floods of 2022 on unusually heavy rains, climate change, the indiscriminate construction on natural flood plains and storm water paths together with poor drainage systems in many residential areas which, clogged channels with waste. Lax enforcement of environmental laws has only exacerbated problems even further. Also the flooding was heightened by the release of water from the Lagdo Dam in neighbouring Cameroon, which affected Nigeria, Niger, Chad, and the surrounding region.

According to Amangabra and Obenade (2015), in 2012, floods resulted in 363 fatalities, 2.1 million people being relocated across states, and 18,282 injuries happened. Nigeria suffered cumulative losses from floods of more than $16.9 billion in 2012 in terms of damaged properties, oil output, agricultural losses, and other losses. Numerous lives and homes have remained at risk as a result of increased flood episodes, a lack of coping mechanisms, and a high level of vulnerability among the populace (Komolafe *et al.,* 2015). Similar unfortunate events occurred in August 2011 in the historic city of Ibadan, which resulted in the loss of many lives and the destruction of property valued at N20 billion.

Over the past years, advances in the disciplines of remote sensing (RS) and geographic information systems (GIS) have greatly improved the operation of flood mapping and flood risk assessment. It is obvious that GIS plays a vital role in the management of natural disasters given the complexity of such events and their inherent spatial component (Coppock, 1995). The main advantage of using GIS for flood control is that it not only creates a visualization of flooding but also enables additional analysis of this product to determine the likely extent of flood damage (Clark, 1998). Remote sensing, GIS, and other technologies have lately undergone substantial advances in the management of flood threats.

Causes and Effects of Floods

The majority of Nigeria's flooding is related to human activity. In Nigeria, flooding has been linked to a number of human activities, including deforestation, careless trash disposal in drains, unchecked urbanization, insufficient or nonexistent environmental infrastructure, a lack of institutional capacity and coordination, inadequate early warning systems, and a lack of public awareness (Yerima and Bello, 2014; Echendu, 2020). According to the Nigeria Hydrological Services Agency (NIHSA) (2020), the causes of recent flooding disasters in Nigeria include the soil moisture regime of lower plains during the height of rainy seasons, extreme weather caused by climate change, dam releases by neighbouring countries, topography, insufficient drainage systems in urban areas, clogging of river channels with wastes, deforestation, obstruction of drainage channels, poor waste management, and extreme weather conditions. In most circumstances, it is difficult to estimate the cost of damages and recovery after disasters since they typically cause great suffering and significant economic losses (Adedeji *et al.,* 2012).

Global flooding has caused enormous socioeconomic costs as well as a significant loss of lives. According to Global Facility for Disaster Risk Reduction (GFDRR, 2015) estimates, during the previous 20 years, natural catastrophes have affected 4.4 billion people, claimed 1.3 million lives, and resulted in $2 trillion in global economic damages. Additionally, it notes that more than 80% of all lives lost in catastrophes in

low- and middle-income nations over the past 30 years, has caused national economies to suffer significant losses of 5 to 120 percent of their Gross Domestic Product (GDP). The impact of catastrophes on GDP is further stated to be 20 times greater in developing countries than in developed/industrialized countries. As the size, frequency, and severity of natural disasters continue to increase, future losses in the environment are anticipated to climb. An estimated rise in the yearly losses due to natural catastrophes from $300 billion to $415 billion by 2030 has been reported by Global Facility for Disaster Reduction and Recovery (GFDRR) (2015).

Effects of Flooding

The effects of flooding can be divided into 2 categories:

- Floods caused by the rivers' lower and middle courses (plain floods). They are more common in the case of long-term precipitation. The waters overflow and encroach on the main riverbed.
- Floods produced in the upper courses of rivers (floods in mountain areas). They occur as a result of relatively short but heavy rainfall. The water level rises quickly (flash flood) and large amounts of solid materials are often transported. The effects of the floods are noticeable as negative, but although it seems hard to believe, the effects of the floods can also be positive.

1. The negative effects of floods are felt especially in areas where local communities have developed or in the case of productive lands. Negative effects of floods include:

- Injuries and life losses;
- Material losses and considerable economic costs,
- Water saturation of the soil and subsoil and damage to crops;
- Leaching nutrients from soils;
- Damage to the environment and cultural heritage.

2. The positive or beneficial effects of floods consist of:

- The large supply of water which leads to the recharging of river courses, surface reservoirs (lakes) and underground aquifers;
- Soil fertilization due to the proliferation of microscopic freshwater algae that fix nitrogen in flooded areas;
- Improving the quality of downstream waters by retaining many pollutants by plants and soils of alluvial plains that are a natural filter.

Agricultural Production and Flooding

In emerging nations, agriculture is the cornerstone of economic growth, development, and the eradication of poverty. Agriculture has historically been seen as the key to and cure for economic development. The agricultural sector will determine whether or not we succeed in achieving long-term economic growth. According to Kuznetz (1973) and Abayomi (1997), the agricultural sector makes four major contributions to the development of an economy: product contribution, factor contribution, market contribution, and foreign exchange contribution. As a natural source of food and raw materials for the industrial sector, agriculture provides raw materials for industrial use to accelerate industrialization. This entails growing crops, raising livestock, forestry, fishing for human consumption and use, and processing and marketing agricultural products. These contributions have, in fact, created chances for lucrative work, which has consequences for reducing poverty and enhancing income distribution. Additionally, the relief of balance-of-payment difficulties in the majority of African countries has been significantly aided by foreign earnings through the exportation of agricultural local commodities. Based on these contributions, agriculture is recognized as the cornerstone of a country's socioeconomic development (Ahmed, 1993).

Flooding has a wide-ranging impact on agricultural production and productivity. Many

crops are destroyed and cannot be recovered after a flood. Livestock is lost or displaced, fish are displaced from water bodies or ponds with weak structures, and livestock grazing lands are also lost. When livestock is not completely lost, they are frequently affected by a variety of diseases as a result of exposure to contaminated flood water. Farmers who are displaced find it difficult to grow crops and raise animals.

Heavy rainfall and flooding have a significant impact on agricultural lands as it washes away the richest part of the soil, which contains organic matter and other crop nutrients, and deposits it elsewhere. This eventually reduces the fertility of the soil and its long-term use. Crop roots fail to respire in waterlogged conditions caused by flooding, as anaerobic conditions develop. Beneficial soil microbes die, and anaerobic organisms take over, producing toxic byproducts that can kill crops or cause chemical reactions that are harmful to crops and soil fauna. In general, heavy rains and flooding are bad for agricultural production. Too much rain and flooding harm crops in the fields, drown livestock, destroy farmlands, and wreak havoc on stored agricultural products farmers could contribute significantly.

Flood Forecasting and Management

The three primary phases of the flood disaster management cycle are flood readiness (before a flood), flood response (during a flood), and the final step, dubbed flood mitigation (after a flood has occurred). Flood preparedness entails identifying places that are frequently affected by flooding, identifying locations that are likely to be affected by a flood, and establishing the best escape routes. When a flood disaster occurs, urgent action must be done to identify the affected area, determine the amount of the flooding, compile damage figures, monitor the flood's course and severity, and other factors that can aid in carrying out relief and rescue efforts on the ground. After a flood has occurred, the flood mitigation phase begins with the assessment of flood hazard and risk vulnerability, river course alterations brought on by flooding, the status of flood control projects, river bank erosion, and drainage congestion.

Flood Preparedness

Rapid and accurate flood forecasting is essential for safeguarding infrastructure and people. Hydrological and meteorological observations are frequently combined in flood forecasting. These systems can range from sophisticated watershed scale model projections to simple river gauges that alert a particular population in advance of increasing river levels. Geostationary satellites and polar-orbiting satellites are utilized for monitoring weather patterns and giving broad coverage imaging, but they only provide data with low spatial resolution when it comes to large-scale flood forecasts.

Satellites are highly helpful in places where severe rains may occur upstream and in less populated areas with few meteorological instruments, even though they are not as accurate as rain gauges or radar. It is preferable to cover small areas with aerial imaging or satellite imagery that has very high spatial resolution data (such as aerial photography, Quickbird, Ikonos, or Worldview). The ideal application of high spatial resolution imagery is to map important infrastructure over smaller areas because it is typically rather expensive.

Through the use of remotely controlled river gauges and an SMS alert system, community-based early warning systems have been built in several nations. When river levels reach a certain level, this comparatively straightforward but efficient combination of technology can send text message alerts. Data collection on the ground is nearly impossible in nations where security issues or logistical difficulties exist.

Monitoring Floods in Real Time Using Remote Sensing

To lessen the effects of flood occurrences, early identification and community alerts are both essential. River gauges, weather forecasts, and

model predictions are frequently used in warning systems. But despite its growing popularity, spatial remote sensing has several drawbacks. For use in monitoring flood occurrences, high-resolution satellite imagery has one significant drawback. Cloud cover frequently limits the use of satellite photography. When it comes to making quick measurements of the earth's surface despite dense cloud cover, Synthetic Aperture Radar (SAR) steals the show.

Remote sensing technologies can be used to evaluate the efficacy of flood mitigation measures like levees or flood barriers while a flood event develops. During a flooding event, aerial imaging can be used to assess the effectiveness of these flood control structures and to spot any potential failure zones, overtopping, or weak spots.

POST-FLOOD RECOVERY

The assessment of flood levels typically takes place after the incident, and when information is being gathered and reported, this is labor-intensive and subject to human error. The mapping of post-flood river morphology, identification of bank erosion, and updating or creating flood risk zone maps, if they don't already exist, are all necessary for preparing for future flood events. Residents can be better prepared for flooding the next time if they have access to up-to-date maps of flood risk zones. However, it has never been easy to verify flood levels on the ground. Again, this is where citizen science platforms and social media can be beneficial. Water levels in city streets can be estimated using geotagged photographs of floods.

For accurate mapping of flood extents and assessing flood damage thereafter, remote sensing is frequently used. High-resolution imagery of the area taken before and after the event can be used to assess the effects of flood events.

Approaches To Flood Mapping and Modelling

Geography, remote sensing and statistics are all used in flood modeling studies. For the purpose of obtaining flood risk mitigations, approaches to flood modeling necessitate multidisciplinary labour (Khorram 2012). Progress in flood risk management in affluent nations like the United Kingdom, United States, and the Netherlands has been dependent on data accessibility, access to up-to-date data, and quick bureaucratic processes (Nkwunonwo *et al.,* 2020). Developing nations hardly ever experience these situations. In the last 20 years, Geographic Information Systems (GIS), hydrological modeling, and the fitting of probability distributions have been the most extensively utilized methodologies for modeling floods in Nigeria (Favorskaya and Jain, 2017; Pourghasemi and Gokceoglu, 2019). Below are examples of how to use these strategies specifically.

Geospatial Techniques and Geographic Information Systems (GIS)

In Nigeria, using remote sensing and GIS techniques to define and map flood-prone zones is the most used method. To study the frequency of floods in the city of Kaduna, Jeb and Aggarwal (2008) used GIS, remote sensing, a digital elevation model, and the Gumbel extreme value distribution. According to the report, there was a significant danger of flooding in locations adjacent to the river Kaduna.

Ojigi *et al.,* (2013) identified the regions damaged by the 2012 floods in five states in Nigeria's north central region using satellite images, base maps, the Shuttle Radar Topography Mission (SRTM), GPS coordinates, and survey data. The study generated a 2012 flood extent map, identified and classified highly flood-prone locations, and in particular showed that Kogi state held more than half of the IDPs within the study area.

With the use of the intermediate resolution image Spectroradiometer and the geospatial technique, Nkeki (2013) assessed the flood risk along the Niger Benue basin for the 2012 flood.

In a geographical examination of flood risk in the Aba metropolitan, Njoku *et al.,* (2013) employed GIS techniques and discovered that locations between 35 and 39 meters and 43 and 48 meters above sea level are particularly vulnerable to flooding because runoff from higher altitudes flow through lower elevations. Runoff and river flow are increased as a result of agricultural practices, deforestation, and the fast expansion of barren land (Kabanda 2013).

The Abakaliki LGA's flood vulnerability map was created using GIS and remote sensing, and it identifies the axis along the River Ebonyi as a particularly high-risk flood region.

Wizor and Week (2014) mapped and analyzed the 2012 flood in Yenagoa, Bayelsa State, using geospatial tools and statistical analysis, and they discovered that 7% of Yenagoa LGA's total land area was impacted. The research classified Yenagoa's land uses into four categories: agriculture, waterbodies, forested regions, and built-up areas. It concluded that 50.6% of the flooded land was in built-up areas. Using ArcGIS 10.0 software, Akukwe and Ogbodo (2015) produced a vulnerability map of the city of Port Harcourt. Thirteen distinct zones made up the city. Flooding susceptibility is more prevalent towards the north-west, south-west, south, and north-east of an area and less prevalent in the center. The distances to waterbodies in the city cause these variations in vulnerability. In Aba, Abia state, Ogbonna *et al.,* (2015) investigated the link between topography data and rainfall patterns. While the Mann-Kendall analysis of the rainfall trend showed that rainfall did not considerably increase the flood danger between the years 2000 and 2010 in the city, the researchers discovered that 72% of Aba is vulnerable to flooding, with the exception of locations around the Ogbor hill axis. Topography, poor drainage, and construction near rivers are other important factors contributing to increased floods in the area.

In Surulere, Lagos, flooding, Okoye and Ojeh (2015) discovered causative elements that were essential. A digital elevation map was created using GIS. They came to the conclusion that Surulere is prone to floods based on elements including high rainfall and duration, urbanization, and soil impermeability. The significance of GIS in mapping flood-risk zones throughout the Niger-Benue River basin was demonstrated by Akinbobola *et al.,* (2015). According to these authors, 45% of settlements in Nigeria are located in flood-prone areas. Dalil *et al*., (2015) used the ArcView GIS package to map the flood-prone areas in Minna, Niger State, and discovered that human activity along the River Suka's bank, such as building on waterways, installing insufficient or poor drainage systems, and the area's geological relief, is the primary cause of flooding there.

Hydrological Modelling and Fitting Probability Distributions

Another method for modeling flooding data is to combine hydrological modeling and extreme value distributions (Adeogun *et al.,* 2019). Although it is clear that this method is not yet commonly employed in Nigeria to predict floods. (Garba *et al.,* 2013a) investigated the influence of climate change on the Kaduna River using hydrological modeling with a stochastic weather generator. According to the modeling results, the river basin's monthly discharge peaks in June and August, presenting opportunities for risk mitigation. In a separate study, these authors employed a calibrated hydrological model to replicate the Kaduna River's hydrology. Prior to calibration, the authors performed a sensitivity analysis of the flow parameters on the hydrognomon model, and they found that flow recession parameters in the initial soil storage and initial groundwater storage were the most sensitive, whereas capillary flow was insensitive. Because model parameters cannot be assessed directly due to unknown elements of physical processes and characteristics at the river-basin

scale, the hydrognomon model was calibrated to rainfall data to provide model parameter values. According to the Nash-Sutcliffe model efficiency finding, key factors in hydrological modeling of the Kaduna River basin include initial ground storage, coefficients of inner flow, percolation, surface runoff flow, and base flow (Garba *et al.,* 2013b).

Using average monthly rainfall data from the river Kaduna for calibration and validation, Garba and Chukwujama (2016) proposed a hydrognomon model for flood-level prediction and came to the conclusion that this model accurately forecasts flood levels. In order to identify the watershed region, Adeogun *et al.,* (2014) used the hydrological modeling approach with a Soil and Water Assessment Tool (SWAT) to simulate and anticipate the Jebba Lake upstream watershed flow. Ndulue *et al.,* (2018) also used a SWAT model to simulate streamflow and sediment discharge yield in the upper Ebonyi watershed. This model showed promise as a useful tool for watershed management, as demonstrated by the R-square, Nash-Sutcliffe model effectiveness, and percent bias as indicators of model fit.

Other Approaches to Flood Modelling

Time-series linear statistical models and more current machine learning methods are combined in data-driven models. For forecasting time-series data, combining suitable linear and nonlinear models gives the possibility for more precise prediction than a single linear or nonlinear model does (Babu and Reddy, 2014). In comparison to process-based models, the data-driven method is strong, quick, and simple to design, and it has shown to be successful when compared to rival models (Phan and Nguyen, 2020). As a result, this methodology has been used in research that estimate the hourly wind speed, the consumption of natural gas, and the output of oil wells. Recent advances in data-driven modeling of water-level discharge provide useful information for efficient management of water resources (Phan and Nguyen 2020; Xu *et al*., 2019).

Another method used to simulate extreme occurrences, such as excessive precipitation and sea-level yearly maxima, is Bayesian statistical methodology, which is based on probability models. Studies in this field are essential to measure and forecast precipitation extremes for the sake of flood planning, and this potent technique is being employed in statistics more and more (Fan *et al.,* 2021).

Conclusion

As observed in the study, flooding being a disaster is unavoidable but can be managed if appropriate measures are instituted. Flooding has negative implications on the environment, economy, and social lives. As noted in the study, flooding affects physical developments such as houses, roads and other structures. In cases of serious flooding, lives are lost in the process.

Application of remote sensing and GIS is convincingly a very efficient way of flood management. Since the problem of flood is very acute in Nigeria, special attention should be given to deal with this problem.

GIS models having simple data requirements are likely to attract the local authorities and can be adopted as an essential input towards a comprehensive flood management system. In the age of all-embracing flood plain management, these sophisticated technologies can be very useful for planners to formulate effective strategies for combating the perpetual natural disaster of flooding in other to reduce its effect on agricultural productivity in the nation.

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Impacts of Flooding on the Aquaculture Sector

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Abstract: Flood is an unusual weather-linked phenomenon associated with climate change. It is an extreme weather event attributed to a rising global temperature which results in heavy downpour, rise in the sea level and glacier melt. These outcomes cause the ocean water to inundate coastal lands. Floods exert both negative and positive consequences on the ecosystem. Besides displacement of people and communities, destruction of farmlands and businesses, flood claims lives of animals as well as humans. It also leads to severe hardship. All these have been witnessed in the last three to four months in Bayelsa State and its environs and also the Northern part of Nigeria. The resulting hardship lingers on as food items e.g., rice, are still being sold at high costs, attributable to the flood event. Flooding also brings about many long-term challenges to the affected areas. The devastating effect of flood is not limited to loss of life and damage to property. A lot of people especially the rural dwellers rely on agriculture for their livelihood. They lose their crops and livestock (e.g., aquaculture) including infrastructures e.g., market places, to floods. Positive effects of floods include recharging of the groundwater and wetlands. Aquaculture contributes to total fisheries production which is of immense benefits to mankind. This paper outlines some of the impacts of flood events on aquaculture as well as preventive strategies to mitigate potential damages and economic losses to individuals and aquaculture operators, which are of great concern.

***Keywords*:** Economic development, fish pond, food security, livelihoods, preventive strategies.

CITATION:
Afia, O. E. and Iwatt, I. J. (2023). Impacts of Flooding on the Aquaculture Sector. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp.333-340

Introduction

Aquaculture is the farming of aquatic organisms such as fish, molluscs, crustaceans, and aquatic plants. Farming implies some sort of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators and general management practices. This farming proce**ss** is noted to have been in practice since after the World War II (Troell *et al.,* 2014). Aquaculture sector plays a key role in food security at the household and national levels (Pradeepkiran, 2019). Today, aquaculture production is important to livelihoods, food security, and economic development in many countries (Hishamunda *et al*., 2009). Climate and extreme events, such as high floods and seasonal droughts, already have significant impacts on production and profits. According to Ghorbani *et al*., (2011), flood is one of the calamities or a natural disaster caused by the overflow of water in a dry region not normally submerged. It could also be described as the inundation of an area not normally covered with water, through a temporary rise in level of stream, river, lake or sea (Agbonkhese *et al*., 2014).In some parts of the world, global climate changes exhibit increasingly severe weather effects on agriculture by extreme flood (Rutkayová *et al*., 2017). The rise in the sea level occasioned by global climate change is one of the causes of flooding (Chukwu Okeah *et al*., 2018). Global

climate change such as thermal expansion of ocean waters and melting of land-ice due to higher ambient temperatures cause the sea level to rise (Cazenave and Llovel, 2010). Besides the rise in sea level, flooding comes from the high rainfall, run off from rivers and urban channels, tidal movement and wind (Okeke, 2003). Human activities like over urbanization, deforestation to make residential societies, poor drainage systems, limited number of dams and embankments are also reasons for flooding (Aldardasawi and Eren, 2021).

However, floods have some positive impacts on aquatic life as it results in nutrient deposition and favorable habitat for most species. Floods also leave after-effects on the macro invertebrates like small insects, which are primary role players in the ecosystem's food chain (Aldardasawi and Eren, 2021). Other positive effects of floods include recharging of the groundwater, recharging of the wetlands and recoating soil fertility (Poff, 2002).

Aquaculture, an Alternative to Land-Based Agriculture

A lot of people especially the rural dwellers rely on agriculture for their livelihood. River erosion, sedimentation and inundation cause floods that washed away a huge part of cultivable land leading to infertile lands and decrease in agricultural productivity. Aquaculture which is a means of obtaining food from the aquatic environments offers a good alternative to land-based agriculture. Aquaculture typically involves the enclosure of a species (Table 1) in a secure system under conditions in which it can thrive. Interventions in the life cycle range from exclusion of predators and control of competitors (extensive aquaculture) to enhancement of food supply (semi-intensive) or even the provision of all nutritional requirements (intensive). Intensification of production also implies increasing the number of individuals per unit area, which decreases the local demand for land/sea space but rather requires greater use and management of inputs, management of waste products and a dependence on technology and fossil energy. Aquaculture is an economic activity that uses and transforms natural aquatic resources into commodities valued by society (Naylor *et al*., 2000). Aquaculture provides significant livelihood, employment and other ecological, social and economic services to people (Subasinghe and Phillips, 2010).

Health and Nutritional Benefits of Aquaculture

Aquaculture contributes towards better human health and better ecosystem. It provides income to the farmers and nutrition to the consumers. Protein is important for growth and development of the body, maintenance and repairing of worn-out tissues, and production of enzymes and hormones required for many body processes (Mukhopadhyay, 2019).

Fish is the primary source of protein for about 950 million people worldwide and represents an important part of the diet of many more. And globally, fish provides about 16% of the animal protein consumed by humans and are a valuable source of minerals and essential fatty acids. Fish is the primary source of omega-3 fatty acids in the human diet. Fish diet plays a vital role in controlling the malnutrition problem especially in young children (Pradeepkiran, 2019) Fish contribute more to people's diets than just a protein source. Minerals such as iron, calcium, zinc, iodine, phosphorus, selenium, and fluorine are gotten from fish and other sea foods. These minerals are described as highly "bioavailable," which means that they are easily absorbed by the body. Fish is a rich source of vitamins A and D, thiamin, riboflavin, and niacin (vitamins B1, B2, and B3). Vitamin A is required for normal vision and for bone growth. Vitamin D which is present in fish liver and oils is crucial for bone growth because it is essential for the absorption and metabolism of calcium. Thiamin, niacin, and

riboflavin are important for energy metabolism. Iron is important in the synthesis of hemoglobin in red blood cells. Hemoglobin is important for transporting oxygen to all parts of the body.

Table 1: Major Species Produced in World Aquaculture

Major Aquaculture Species Produced in the
Finfish
Grass carp (*Ctenopharyngodon idellus*)
Atlantic salmon (*Salmo salar*)
Striped catfish (*Pangasianodon hypophthalmus*)
Roho labeo (*Labeo rohita*)
Milkfish (*Chanos chanos*)
Torpedo-shaped catfishes (*Clarias* spp.)
Tilapia (*Oreochromis* spp).
Rainbow trout (*Oncorhynchus mykiss*)
Wuchang bream (*Megalobrama amblycephala*)
Marine fishes (Osteichthyes)
Black carp (*Mylopharyngodon piceus*)
Cyprinids (Cyprinidae)
Yellow catfish (*Pelteobagrus fulvidraco*)
Silver carp (*Hypophthalmichthys molitrixI*)
Nile tilapia (*Oreochromis niloticus*)
Common carp (*Cyprinus carpio*)
Bighead carp (*Hypophthalmichthys nobilis*)
Catla (*Carassius* spp.)
Crustaceans
Whiteleg shrimp (*Penaeus vannamei*)
Red swamp crawfish (*Procambarus clarkia*)
Chinese mitten crab (*Eriocheir sinensis*)
Giant tiger prawn (*Penaeus monodon*)
Oriental river prawn (*Macrobrachium nipponense*)
Giant river prawn (*Macrobrachium rosenbergii*)
Molluscs
Cupped oysters (*Crassostrea* spp.)
Japanese carpet shell (*Ruditapes philippinarum*)
Scallops (Pectinidae)
Sea mussels (Mytilidae)
Marine molluscs (Mollusca)
Constricted tagelus (*Sinonovacula constricta*)
Pacific cupped oyster (*Crassostrea gigas*)
Blood cockle (*Anadara granosa*)
Chilean mussel (*Mytilus* chilensis)

Source: (FAO, 2020)

Calcium is required for formation and mineralization of strong bones, and for the normal functioning of muscles and the nervous system. It is also important in the blood-clotting process. Vitamin D aids in its proper absorption. The intake of calcium, phosphorus, and fluorine is higher when small fish are eaten with their bones rather than when the fish bones are discarded. Zinc is required for most body processes as it occurs together with proteins in essential enzymes required for metabolism. Zinc plays an important role in growth and development as well in the proper functioning of the immune system and for a healthy skin. Iodine, present in seafood, is important for hormones that regulate body metabolism and in children it is required for growth and normal mental development (Pradeepkiran, 2019).

Other Causes and Types of Flooding

Life at the water–soil boundary is exposed to recurring floods, in particular due to seasonal rain and thaw, summer inundations or other weather extremes (Graupner *et al*., 2017). Floods are affected by many factors, some of which are the amount and type of precipitation, temperature, previous weather, the possibility of runoff, permeable or waterproof base, soil (extremely dry or highly saturated), geographic situation in the region, land use, terrain slope, water level, and water storage space (lack of water storage capacity in the ponds) etc. Cases of no clear definition of the extremity and their likely outcome are recorded as extreme floods (Rutkayová *et al*., 2017). Climate change, rapid urbanization, poor solid waste management, inadequate maintenance of water, and wastewater infrastructures are factors that lead to flooding. Climate variability makes the weather less predictable, especially in developing countries like Nigeria where facilities to predict and manage weather conditions are not adequate. Climate change works in an indirect way to aggravate flooding

by altering the pattern of flooding in the flood prone areas (Agbonkhese *et al*., 2014).

Flooding, by its very nature, can be resulting from both meteorological and hydrologic processes; the character of a flood is determined both by the detailed behaviour of the precipitation and by the nature of situation in which the event is likely to occur (soil conditions, amount of antecedent rainfall, etc.). Atmospheric processes such as precipitation can be identified as being directly responsible for a flood event. For example, when rainfall occurs beyond the average values for the affected area, exceeding the average that land which is usually dry can be absorbed. A precipitation event that causes a flood in one location might be well within the bounds of what is typical for another location (Fry *et al*., 2016). Notably, the threshold for flood-producing rainfalls increases as the annual average rainfall for a region increases (Doswell, 2003). A flooding event may be described as follows (Aldardasawi and Eren, 2021): Areal Flooding, Riverine flooding, Coastal flooding and Urban flooding.

Areal flooding occurs in such areas which have low lying landscape. Heavy rainfall in such low-profile areas is the major cause of floods. Overly saturated soil in such plain areas will no longer be able to absorb the water and will cause the flooding of water. Riverine flooding occurs in small rivers and streams due to heavy rainfall in the monsoon or due to the melting of glaciers in summers. Heavy rainfall events and other discharges into river cause the river to rise gradually in response (to all the input rainfall). The river flood potential can be increased by concurrent snow melt and other factors besides rainfall (Doswell, 2003). Urban flooding occurs mainly in densely populated areas due to improper and inadequate drainage systems. Heavy rainfall results in an overflow of the inbuilt capacity of drainage systems and eventually results in urban flooding, wreaking havoc on the infrastructure and livestock of urban areas (Aldardasawi and Eren, 2021).

Other forms of flooding are flash floods, breaching of a dam or levee and dam spills. Flash floods are those flood events where the rise in water is either during or within a few hours of the rainfall that produces the rise. Many hydrological factors such as terrain gradients, soil type, vegetative cover, human habitation, antecedent rainfall, have relevance on the occurrence of a flash flood. Even a relatively small amount of rainfall can trigger flash flooding in steep, rocky terrain or within heavily urbanized regions (Doswell, 2003).

The rapidity of the event makes flash floods so damaging and dangerous as people are caught unawares. Most fatalities result from drowning, with perhaps some traumatic injuries from being carried along in the debris-laden waters and being swept into standing objects. The potential for loss of human life with flash floods is high. Debris carried in flash floods can form temporary 'debris dams' that typically fail as waters back up behind them. Failure of these debris dams then results in a 'wall of water' surging downstream. Debris dam failure events can happen repeatedly during the course of the flash flood. All flash floods involve rapidly rising floodwaters. Because urbanized areas promote runoff of rainfall, rather than permitting most of the rain to be absorbed into the ground, flash flooding is more likely in cities than in rural areas surrounding a city. It takes much less rainfall in a city to create a flash flood situation than in a rural area of comparable size (Fry *et al*., 2016).

Impacts of Flood

Floods connect rivers with floodplains and supply nutrients and organic matter to aquatic–terrestrial transition zones, stimulating biological productivity and habitat heterogeneity. Floods induce environmental changes. These changes are capable of stimulating fish productivity and increasing

species abundance, richness, evenness, and diversity compared to stable flow regimes. Structural indices of some fish communities however, may not be affected by floods. The effects of floods are mediated by the magnitude, frequency, duration, timing, and rate of change of water levels. Flood impacts may also vary according to fish age, morphology, physiology (such as turbidity tolerance, swimming strength), behavior (such as movement, habitat use), and community composition e.g., species abundance, diversity (Carlson *et al*., 2016).

Floods may also exert differential effects on introduced and native fishes. Although native fishes may be more adapted to flow regimes in their indigenous range (Carlson *et al*., 2016), both native and introduced species may benefit from river floodplain connectivity and become more abundant after floods (Stoffels *et al*., 2014). In some rivers, floods increase reproduction, recruitment, and population growth of introduced fishes to a greater extent than native species.

Flooding alters flow regimes within streams (Poff and Zimmerman, 2010), the flux of nutrients has been reported by Bardgett *et al.,* (2001) as well as changes in nutrient cycles.

Flood waters carry enormous amounts of debris, sediments, and hazardous pollutants into water bodies; sediment accumulations from flood water reduce water depths. Toxins and pathogens such as viruses and bacteria are transported along with contaminated sediments and floating debris (Greater Houston Flood Mitigation Consortium, 2018). The phenomenon of flooding is of concern when places important to humans are affected. Flooding can cause sewage treatment systems to fail. Untreated sewage can overflow as a result of flooding thereby releasing intestinal bacteria into floodwaters. People exposed to these infectious agents either from direct use of the water or through the consumption of the sea foods can develop intestinal distress and debilitating disease symptoms. Other floodwater-borne pathogens such as *Vibrio vulnificus* can cause severe forms of illness, such as necrotizing fasciitis and sepsis (Greater Houston Flood Mitigation Consortium, 2018).

Flood causes the mobilization and deposition of harmful materials like pesticides, pathogens, and other hazardous materials to the rivers, ponds, streams, and groundwater making these resources unfit for consumption and habitation by the sea foods species and also for human use. Flooding affects the quality of water as well as the state of fishes (**Chukwu Okeah *et al*., 2018)** due to the various depositions. Flooding contaminates the water and makes the ecosystem toxic and inhabitable (Aldardasawi and Eren, 2021).

Extreme floods change the geomorphology of the rivers which the quality and quantity of aquatic life entirely depend on. Geomorphology is the nature of the aquatic system and any alterations affect the organisms residing therein. The flood can cause their displacement and loss of their habitat (Death *et al*., 2015).

The impacts of flood on aquaculture are of great concern as it causes serious damage and economic losses to individuals and the aquaculture companies. Some of the impacts of flood events on aquaculture are summarized as follows:

i. **Disruption of fish assemblage:** Flooding causes disruption of fish assemblage and changes in the population of various aquaculture species. The components of the flooding water some of which are harmful can cause deleterious effect on aquatic animals, particularly fish. Even at low concentrations, ammonia is reported to induce high level of toxicity in fish (Adewumi, 2015).
ii. **Fish mortality:** Fish mortalities is likely to occur during floods and can be direct or indirect. Floods cause direct mortality not

only in juveniles but also in adult fish. The direct causes could occur if a pond's dam is ruptured; flood waves spill over a dam; water floods the surrounding area or there is a sudden change of the environment due to water quality or debris flow. The indirect causes of fish mortalities can be the bringing of undesirable, invasive species, and parasites of fish into fish ponds for the aquaculture or the excessive biological decomposition of organic matter (Aliyas, 2019).

iii. **Reduction in dissolved oxygen (DO) level:** Dissolved oxygen is an important component of aquatic systems. Changes in its concentrations have major impacts on the global carbon and nitrogen cycles (IPCC, 2014). The introduction of debris especially of biological origin into the aquaculture farm affects the oxygen content of the fish pond. In the cause of the decomposition of the deposited materials by microorganisms, the dissolved oxygen is used up leaving little or none for the aquaculture species. The anoxic condition of the water results in fish kills (mortality) or dead of the species due to lack of oxygen.

iv. **Fish migration:** Floods are able to cause fish migrations in stream waters, in reservoirs and lakes, and also in pond systems (Rutkayová *et al*., 2017). Fish migrations depend on the particular fish species involved, the season, inflow rate of surface waters and any manipulation of water levels by human water management authorities. Depending on fish species, their age and size, individual species behave differently under flood conditions.

Downstream migrations are rather typical for the majority of the carp species. On the contrary, hatchlings of catfish, turbot, and peled (*Coregonus peled*) tend to migrate on every possible occasion, including situations when the water flow rate is minimal. The losses (downstream escapes) are in these cases usually almost 100% (Arán, 2019)

v. **Disruption of the water quality and reduction of the aesthetic value of the water:** The introduction of foreign materials into the pond during flooding affects the primary productivity of the aquatic ecosystem. The primary producers in the natural water are also sources of carbon, energy and nutrients to the fishes and other aquaculture species. Flooding changes the clarity, pH, and other parameters of the water which have vital roles in the survival and productivity of the species.

Flood events cause economic losses and damages that reach enormous sums: the fish from ponds often end up stranded on the flooded fields, on the roads etc. and are lost entirely (Rutkayová *et al*., 2017).

Preventive Strategies

One of the basic rules of prevention of fish stock losses is to use the natural conditions in places where fish are kept and to appropriately use the inundation. Every fish pond used for aquaculture should meet the technical requirements of water works and adhere to the principles of technical and safety supervision. This reduces the possibility of damaging water works and also potential economic loss. The worst cases occur when the pond dam is ruptured by flood action and ponds are left completely devoid of fish (Rutkayová *et al*., 2017). Other management strategies include: the retreat strategy, accommodation, early warning and emergency management systems and construction of embankments.

Conclusion

Flooding is usually considered a significant natural hazard causing disease, damage and loss to life, property, and infrastructure as well as disruption of public services. For example, floods can cause dangerous landslides loss of crops and livestock, disruption of normal drainage systems, spillage of raw sewage and animal waste, and accelerated discharge of industrial and urban toxic materials and nutrients into waterways. Because of their dramatic effects on people and infrastructure, the effects of flooding on aquatic ecosystems are often viewed as negative; however, this is not always the case. Flooding can also provide many benefits, including recharging groundwater, increasing fish production, creating wildlife habitat, recharging wetlands, constructing floodplains, and rejuvenating soil fertility. Since the effects of flooding on aquatic ecosystems can be both negative and positive, ecosystem services should also exhibit a mix of negative and positive outcomes resulting from flooding. Floods occur when low-lying areas that are typically dry become temporarily inundated with water outside of their normal confines (Talbot *et al*., 2018). Flood magnitude is only one aspect of predicting flood impacts on aquatic ecosystems and ecosystem services

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Pastoralist, Conflicts and Security In Nigeria; Seeing Through The Lenses Of Climate Change

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Abstract: *Impacts of climate change are heterogeneous across geographical regions, agro-ecological systems and communities. Pastoralists are arguably good adapters to these changes, especially in their adoption of transhumant and nomadic mobility in search of pasture and water for their livestock. Pastures in unfavourable season usually are found across humid zones where the predominant agricultural mainstay is crop production. Consequently, conflicts ensure between farmers and pastoralists, resulting in loss of human lives, rangelands and/or farmlands, livestock and crops. Current climate change projections will further exacerbate the situation, as droughts in the north will be prolonged and flooding in the south will increase. Yet, little emphasis is placed on the consequences of the influx of nomadic pastoralists on an already burgeoning population within the south who themselves are potential victims of projected climate change impacts. In view of these impacts, this paper analyses the ongoing conflicts between farmers and pastoralist in Nigeria, with the objective of highlighting salient climate-related points that will escalate tensions. To avoid the pitfalls of the "tragedy of the commons" and a collapse of the agrarian system, the paper argues against the current practice of open access to rangelands. It proposes a pastoralist concessional licence to rangelands as the way forward to limiting the number of pastoralists on rangelands, including the number of livestock allowed per time.*

Keywords: Agriculture, Ecosystems, Rangeland, sub-Saharan Africa, Farmers

CITATION:

Anwana, E. D. (2023). Pastoralists, Conflicts and Security in Nigeria; Seeing Through the Lenses of Climate Change. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 324-332

Introduction

Pastoralists are people mostly found in arid and semi-arid regions with their livelihoods centred on livestock. Pastoral systems worldwide are linked to specific ecosystems and socioeconomic environments, with the types of livestock kept by pastoralists varying according to climate, environment, water and other natural resources, and geographical area (Rota and Sperandini, 2009). In Nigeria, for instance, the main livestock are cattle, sheep and goats (FAO, 2001). As an economy booster, the pastoralism sub-sector is notably a major contributor. Annual output in 1984 from Africa was worth 10 billion US dollars, compared with total cereal production, valued at 8.4 billion US dollars (Scoones, 1994). In sub-Saharan Africa alone, meat and milk demand are expected to grow by 3.2% and 3.9% per annum between 1997 and 2020 (Rosegrant *et al*., 2001). Also, the livestock sector represents 20% to 25% of agricultural GDP across Africa, and a significant portion of African livestock is found in pastoral areas, thus underscoring their relevance in national development and the region's food security.

Pastoralists are fast becoming ubiquitous across many landscapes in Nigeria, even in elevated montane ecosystems such as those of

Obudu cattle ranch, Cross River State. Their presence in many instances has caused a lot of pandemonium and conflicts within host communities, especially farmers. Between the periods 2005 to 2010 about 280 persons lost their lives (www.apanews.net); and approximately 32 deaths were recorded in 2009 (Integrated Regional Information Networks, IRIN, 2009). In recent times, escalated episodes of bloodshed, rape and wanton destruction have been articulated (see for instance, Okoli *et al*., 2017). These conflicts are somewhat expected as historical narratives are replete with farmers cum pastoralists struggles (e.g., EDC 2001; Pickardt *et al.,* 2002; Sylla, 2003; Opoku, 2014). But situations of conflicts during economic downturns and global terrorism are unsettling and detrimental to the socioeconomic status of any community. Several causative factors have been put forward as reasons for the growing tension between pastoralists and farmers. On one end of the spectrum is the intolerance of livelihood clashes, where crop production, a mainstay of southern farmers, is put at risk by the trampling feet of herded cattle. Others state, the pollution of important water bodies especially drinking streams and rivers. At the extreme is religious stereotyping and intolerance of perceived cultural mores. These polarized views seldom make reference to the growing trends of climate variability and change. Yet, climate change coupled with Africa's peculiar socioeconomic status is perhaps one of the most important environmental stressor of the 21st century and beyond (Millenium Ecosystem Assessment, MEA, 2005)

Climate change is predicted to increase and prolong incidences of droughts, floods, windstorms, fires and pest outbreaks in many parts of the world including Nigeria (IPCC, 2014). Although, Africa is one of the lowest emitter of Green House Gases (GHG) emissions, yet it bears the brunt of global climate change. Africa is primarily an agrarian continent heavily dependent on rain-fed agriculture and lacks the technological expertise to combat the knock-on effects of extreme climate variability and changes. For instance, in Nigeria, most of the irrigation farming systems is located within semi-arid zones such as in Kano States, than in the humid south. Yet, current climate change projections show a high chance of increase in temperature and reduction in precipitation levels (IPCC, 2007; 2014). Instructive, is the recent incidence of the drying-up of a major river in Okwangwo community, Boki Local Government of Cross River State. According to the narrative of the Cross River National Park chief ranger, who moved into the area eight years ago, the present park staff had never witness such occurrences (Personal communication, 2021). Realities such as the dried river might soon become the norm rather than an exception if the 'business-as-usual" stance is adopted. Additionally, a dependence on agriculture and livestock with lack of irrigation implies that African farmers are especially vulnerable to precipitation changes. These changes translate to over-farming, degradation of land resources and increased pressure on wild game species (Fields, 2005), leading to conflicts as farmers and livestock herders search for more arable land and viable alternatives.

Apparently however, pastoralists over time are well adapted to climate variability and changes through the adoption of mobility. Two types of mobility define pastoral systems worldwide; Nomadic and transhumant pastoralism (Scoones, 1994). The term "nomadic" is used when mobility is high and in irregular patterns; whereas "transhumant" when there are regular back-and-forth movements between relatively fixed locations (Rota and Sperandini, 2009). Mobility of pastoralist within the Nigerian clime is usually from the far northeastern states to the south. Thus, in search of water and pasture, cattle and other livestock are moved from semi-arid regions during the dry season to favourable

humid zones. Movement of mobile communities such as pastoralists into southern zones increases population and land-use practices of the area. In terms of resource use, water and forage are most important for pastoralists and changes in their availability greatly influence pastoralists' livelihood security. In a situation of delay onset of rainfall or lack of it, pastoralists are more resistant than farmers. Farmers are affected earlier, because crops are usually lost in the first year of drought. While pastoralists can move their assets (livestock) to areas where forage and water is still available, farmers cannot move their own assets (crops) to where water is available (Nassef *et al.*, 2009). Consideration for both groups (i.e. pastoralist and farmers) assets is equally important in view of food and national security. Also, it is important to note that natural resource capital acts as a safety net for a variety of people involved in agriculture during period of stress, especially in sub-Saharan Africa. Hence, its depletion and degradation will complicate their ability to live with climate variability and change in the future (Paavola, 2008). Against this backdrop, this paper highlights salient climate-related points that will escalate tensions between these two different resource-users. The paper draws its arguments from past literature on open access resources (e.g. Hardin 1968; Ostrom, 1990; Schlager and Ostrom, 1992), and the growing corpus of climate change evidences (Fields, 2005; IPCC, 1996, 2007, 2014; www.unfccc.int).

1. Climate Change; Effects and Impacts

Global climate change driven by increases in the concentration of greenhouse gases in the atmosphere primarily manifests itself in changes to weather patterns at a place and an increase in sea level due to thermal expansion of sea water and inputs from melting land ice. Generally, there is an assumption that pastoral areas face an increased risk of drought events, due to increased variability of rainfall but also higher temperatures, even if mean rainfall is predicted to rise. Likewise, the more humid south will experience more flooding episodes based an accelerated sea level rise (ASLR). Useful as a starting point on impacts of climate change is the report submitted by the Nigerian government, on *Intended Nationally Determined Contribution*, to the secretariat of the United Nations Framework on Climate Change Convention, where the following statement is articulated; "...Climate change would result in increased variability in rainfall, predictably resulting in floods in many parts of the country, particularly the humid areas, with devastating consequences. Single extreme climate events have the potential to wipe out years of development. For example, the total value of destroyed physical and durable assets caused by the 2012 floods has been estimated to be N1.48 trillion (US$9.5 billion) or about 2% of the rebased GDP of US$510 billion. While floods may further ravage the humid areas to the south, a decrease in precipitation is expected in the savannah north. This may result in increased drought frequency and decrease in surface water resources, thus increasing its dependence on underground water sources. The increasing aridity in the northeast of the country has drastically reduced opportunities for sustainable agriculture and is considered a contributing factor to the current conflict and high degree of insecurity in the region (UNFCCC, 2015)

The above quotes show very clearly what the Impacts of climate change will be on the nation's economy. Importantly, as detailed in the report is the increases in drought frequency and decrease in surface water resources highlighted in the text. The boomerang effects will definitely cascade across the two livelihood groups. Of interest also, is the statement on the likelihood of increasing conflict and insecurity. It is important to note that pasture routes are shrinking as climate change takes its toll on

vegetation and biodiversity. Also, soil fertility is widely reported to be on the decrease, thus, necessitating agriculture extensification (Lenton, 2002). Soil fertility decreases as bush fallow periods are reduced and more people farm over and over again on the same area, leading to land degradation. Similarly, land degradation is a big environmental stressor coupled with extreme weather events and climate change, as it taxes the ability of ecosystem to repair itself, thus, affecting the quality of land. Between 10 and 20% of drylands suffer from land degradation (Safiel *et al.*, 2005). Additionally, land degradation affects the provision of ecosystem services, crop and pasture productivity. Moreover, a decline in vegetation cover in a catchment can lead to increased risk of flooding. Different land-use practices, such as for crop production and forage coupled with population pressure in any particular ecosystem brings to fore the carrying capacity of such system. As extreme weather phenomena increases, so also conflict will, as varied population scrabble for ecosystem goods and services.

1.1 Effect on Livelihoods; pasture and crop production

Climate change results in direct changes in crop and pasture productivity, leading in some cases to a change in the frequency of crop and pasture failure (Black *et al.,* 2011). This will seriously impinge on livelihoods and calls for the adoption of climate-smart technology or perhaps livelihood diversification. For pastoral systems and capture fisheries, variability and stability often increases mobility; with fishing communities and pastoralists migrating temporarily or permanently to secure livelihoods (Badjeck *et al.,* 2010). Also, increase in temperatures would increase the frequency of high temperature extremes, particularly affecting crop productivity and ecosystem services (e.g. food and water) ecosystem. Climate impacts will be of various sorts and at various scales, through effects on graze and browse availability, patterns of animal diseases, and possibly heat stress on the animals themselves. All these changes will further drive local economy into high poverty circles, especially amongst the poor population. However, climate alone is rarely the reason people fall into poverty; instead, it interacts with existing problems and makes them worse. For example, migration as a climate adaptation strategy increases population pressure and environmental degradation as earlier mentioned. Furthermore, failed rainy seasons will result in reduced agricultural yields especially in degraded and fragmented landscapes. This, and increased climatic shocks will fuel conflict over resources and access.

1.2 Conflicts and Security Issues

Imobighe (1990) put forward an interesting definition of security. He defined security *inter alia*; "... [As] freedom from danger, or threats to a nation's ability to protect and develop itself, promote its cherished values and legitimate interest and enhance the well-being of its people..."

Freedom from danger implies that the nation's citizens can go about their legitimate livelihood without fear of attack or reprisal based on previous raids and conflicts. But this is not the situation in the never ending crisis between pastoralist and farmers in the country. In other to proffer long lasting solutions, the root causes of the problem must be clearly understood. This will form the basis of any good strategy in ameliorating the situation. As stated in the introductory section of this paper, the root cause of this persistent conflict lies in the paucity of pasture and water. Very significant stress on pastoralism is imposed by cultivation activities where both livelihoods overlap (Dokubo, 2010). For example, the Interior Delta of the Niger and the Senegal Valleys in West Africa, which were traditionally used for wet season grazing, has been converted into cropland (Steinfeld *et al*., 1997).

Furthermore, it's important in this section to reiterate that the impact of climate change in the form of desertification, declining water points and loss of foliage coupled with increasing human and livestock populations has intensified competition over scarce land and water resources and exacerbated relationships between both groups. The jostle for grazing land and watering points for cattle, against farmlands and irrigation sources for crops has caused immeasurable human and material loss and therefore, demands urgent attention (Black *et al*., 2011; Nigeria Stability and Reconciliation Programme, NSRP, 2015). Additionally, NSRP (2015) and Nassef *et al.* (2009) note that many of these conflicts result in restrictions on trespassing on crop fields or livestock drinking water near the fields or from domestic water sources. Sometimes raids are made simply for purposes of revenge on previous clashes. Violence sometimes becomes devastating; burning houses, destroying property, destroying crops, looting of animals, causing injuries and sometimes disabilities in addition to casualties, causing crop fields to be abandoned for lengthy periods of time, and sometimes leading to massive evacuations.

Also, conflicts naturally occur as farmers have to contend over decreasing agricultural lands with herdsmen. However, there is conflicting evidence on this point. For instance, some studies have examined the relationship between temperature anomalies and conflicts, with predictive models suggesting that environmental change will increase conflict (Burke *et al.,* 2009). Some authors contest these results, finding no evidence to suggest future deviation from the historical downward trend in large scale violent conflict and ethnographic studies of conflict find less decisive evidence for the direct links between environmental scarcity and the presence of violent conflict (Buhang, 2010). The conflicting evidences are based on the selection of data sets on which analysis has been conducted, but also more broadly on the nature of conflict; and as such arguments for and against attribution of conflicts to environmental change must be considered within the context of each case study.

Importantly, in recent years, conflicts for accessing land are becoming more destructive because of the proliferation of small arms. Furthermore, climate change effects of both fast and slow onset represent increased hazards that most African states, including Nigeria are ill-equipped to deal with and are likely to continue fueling conflicts. If Imobighe's definition of security is to be taken to heart, it means that internal security must be made robust to accommodate the security of livelihoods and its support systems. Human well-being starts from access and availability of nutritional food. Thus, any threat to food security ultimately compromises a community's well-being.

2.3 Adaptation options

Climate change is here to stay and it's a reality that must be factored into national development planning. In view of this, the various coping measures adopted by the two different livelihood groups should be examined, to determine its strength and weaknesses. This will aid development planners and policy makers make informed judgements. Pastoralists employ several adaptive measures to combat climate variability and change. Primary amongst several options is mobility. Others include, building up herd sizes as insurance against times of hardship, splitting herds across different locations to spread risk, keeping different species and breeds and loaning surplus animals to family and friends – ensure the rational use of the natural resource base and also develop and strengthen social relations as a form of social capital (Tacoli, 2011; Hesse & MacGregor, 2006). Some of these measures are commendable; however, mobility affects other communities. More and more people in this century and beyond will become climate refugees as increased frequency and severity of droughts

and extreme weather events including sea level rise are likely to bring about large-scale movements during the current century (Thorton *et al.*, 2013). But, as argued by some (e.g., Nassef *et al.,* 2009), pastoralists are by their nature adapters, and if left to themselves will adapt, quite possibly more successfully than crop-farmers. Rather than fear for them under climate change, it is preferable to create for them the space, through more enabling policies, to adapt. Wide range policies would be needed to adopt to these greater migratory pressures and in most cases, migration would need to be encouraged and not avoided (Gemenne, 2009). However, successful adaptation across the two livelihood groups will require huge investment in policy and technology.

2. Charting the way forward

In charting the way forward, the Nigerian state is faced with several options. At the baseline, the indifference to climate change must be discarded. Good enough the Federal Government's economic growth plans detailed in Nigeria Vision 20:2020, Economic Transformation Blueprint (2009), recognizes the changing climate as a threat to sustainable growth in the next decade. It sees climate change as a critical challenge. More so, the Federal Executive Council adoption of the Nigeria Climate Change Policy Response and Strategy in 2012 is encouraging. Yet, we must as a nation move beyond lip service to these noble packages and actually engage all stakeholders (including farmers and pastoralist) in conversations centered on strategies of harmonizing food and human security. Perhaps mediators are needed. This has to be done in conjunction with traditional societies and not in abstraction. Hence, as part of the process adopting the bottom-up approach to governance and management of resources is of importance.

Beyond this, context specific packages targeted at different livelihood groups are urgently required. Strategies must include climate sensitive options for both pastoralists and farmers, climate financing options and technology, such as irrigation. Others argued on the adoption of grazing reserves and ranching. Yet, recognizing the need for pastoral mobility and communal land tenure and access right is equally important. Thus, I rather argue for a concessionary legislation.

Open access to grazing grounds in the south should be governed by concessionary legislation and pastoral code. This will limit free range grounds and only designated areas will be conceded for cattle. With no policy on limits of livestock on rangelands, the theory of the tragedy of the commons popularized by Hardin (1968) is bound to occur. Communal grazing and open access lands tends to overstocking and abuse of ecosystems, as individual pastoralist outcompete each other in the number of livestock allowed to graze in a particular area. With no recourse to the carrying capacity of rangeland, the system is bound to collapse. Other suggestions in charting a way forward are as noted by Anderson *et al.* (2009), emphasis are mine:

- Locally-specific climate projections and research on the full range of climate change impacts,
- Pilot dissemination of climate information, at various scales and various timescales, to determine what can be useful to pastoralists (*farmers*) and those who support them,
- Research on the contribution of pastoralism (*farming*) to greenhouse gas emissions, and the positive opportunities for carbon sequestration on rangelands and
- Action to increase pastoralists' (*farmers*) resilience to climate change: in large measure this will coincide with general good practice in pastoral (*and crop production*) development.

Conclusion

Can pastoralist and farmers co-habit in a changing climate and landscape? It seems far-fetched in view of frequent clashes between the two groups. However, a clear characterization of the changes within their common landscapes and communication may be a starting point of conflict resolution between the two groups and other resource user groups. More so, as maintained and argued in this article, policy must evolve which provides the option of concessional rangelands licenses to pastoralists into other communities outside their domain. This will further aid reduction of conflicts, through limiting the number of pastoralists in a particular range including the number of livestock allowed per time and place.

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Climate Change And It's Impact On Fisheries Resources In Niger Delta, Nigeria

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Abstract: *The paper reviewed the impact of climate change on the fisheries resources of Niger Delta. Drawing from a global perspective of Climate change concept impacts on aquatic resources, some of the factors that cause of climate change in the region, such as oil spillage, gas flaring and emission, increased rainfall and oceanic circulation, were identified and discussed. Further elucidation and discussion of specific climate change induced impacts on the fisheries resources of the Niger Delta region were clearly articulated and discussed to include amongst others; mangrove ecosystem degradation, flooding induced impacts, potential catch reduction, degradation of nursery grounds, distortion of fish migratory pattern, reduction in yield, new species invasion, salinity, decreased pH and increased ocean acidification, dominance harmful algal bloom production, etc. Recommendations that were made amongst others on how to reduce the impact of climate change impact on fisheries resources of the region include the following: that all factors known and particularly implicated in this paper considered as contributors to climate change impacts within the Niger Delta region, should be controlled and prevented where possible, Industries in the Niger Delta region and crude oil exploration activities in particular, whose activities emit carbon should reduce their level of carbon emission, by resorting to green energy sources, and that national and sub-national governments in Nigeria, should develop high confidence prediction models of climate change perturbation on fish response in order to get accurate feedback, as well as adaptation to mitigate the impact.*

Key words: Climate-Change, Impacts, Fisheries, Resources Niger Delta, Nigeria

CITATION:

Akankali, J. A. and Jagba, O. G. (2023). Climate Change and It's Impact on Fisheries Resources in Niger Delta, Nigeria. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 314-323

Introduction

Nigeria is a maritime country with tremendous aquatic and fisheries resources that make significant contributions to livelihood, food security and the overall economy of the nation. The country's fresh water and marine fisheries resources are enormous with tremendous opportunities for fish production through capture and cultured fisheries. Nigeria is one of the countries expected to be most affected by the impacts of climate change, through sea level rise along our 800km long coastline, intensified desertification, erosion and flooding disasters and general land degradation. The Niger Delta region of Nigeria has been primed as being highly vulnerable to the impact of climate variability due to its low adaptive capacity and the fragility of the ecosystem (Nzeadibe *et al*., 2012.). The Niger Delta region is located in the Atlantic coast of southern Nigeria where River Niger divides into numerous tributaries. It is the second largest delta in the world with a coastline spanning about 450 kilometers. It is the richest

wetland in the world, highly diverse and supportive of numerous species of terrestrial and aquatic flora and fauna and human life.

The impact of climate change on the aquatic resources of Niger Delta has become highly evident, as signified mainly by the two major flooding that has been witnessed in the region within a decade – the first one in 2012 and the second and most occurring in 2022. The two flood incidents were highly devasting to both the biotic and abiotic aquatic resources of the region, bring in it's massive disruption of physical infrastructure and the sources of lively hoods of mostly the coastal and riverine dwelling communities.

Climate change has affected fisheries through alterations in potential catch due to shifts in species range and decline in primary prey available to the species caused by acidification of the oceans from higher CO_2 levels, loss of coral reefs because of ocean warming, and variations in ocean biogeochemistry, such as oxygen levels (Sumaila and William, 2010). The secondary effects are caused by increased temperature include changes in patterns of precipitation and rainfall, rising sea levels, altered patterns of agriculture, extreme weather events, expansion of the range of tropical diseases, and the opening of new trade routes among others (Ogundele and Jegede, 2011). These secondary events lead to loss of fish stocks, and considerable economic impacts, by damaging fish farm cages. This scenario of sever adverse impacts on fisheries resources of the region, caused either directly or indirectly by climate change has become brought about an enormous amount of decline in yield from both the capture fisheries and aquaculture subsectors of the Fisheries industry in the Niger Delta and Nigeria at large. Consequently, the justification to review the impacts of climate change on fisheries within the Niger Delta region being the focus is this paper is considered quite imperative.

Niger Delta Environment and It's Resources

The Niger Delta Region of Nigeria is the catchment of the river Niger as it enters the Atlantic Ocean in the Gulf of Guinea in a delta form. Other rivers such as Cross River, Qua Iboe River and Imo River to the east and Rivers Forcados the Ethiope to the west, which also empty into the Gulf of Guinea close to the River Niger, join to constitute the catchments, (Uyigue and Agho, 2007). The region lies between latitudes 4°301 and 6°301 north of the equator. The monthly mean temperatures are high, 26.67°C in March/April and 24.44°C in July/ August, giving a small annual range of 2.73°C. Also, the monthly mean relative humidity figures are high, often reaching 90%. Thus, the Niger Delta region has an atmospheric weather cum climate pattern that significantly impacts it's terrestrial environment, the aquatic in particular. In other words, being an ecologically sensitive region having vast wet land and coastal resources, any form of climatic perturbations often leads to significant impacts on it's aquatic resources; fisheries predominantly inclusive.

The Niger Delta region is rich in freshwater resources and by extension freshwater fish species. Most of the fishery activities occur in the coastal states of Nigeria that account for 960km of the coastline, shared by Akwa-Ibom and Cross River States (108 km), Bayelsa and River States (390 km), Delta State (126 km), Lagos State (230 km), Ogun State (18 km) and Ondo State (88 km) (Ayansanwo, 2003). Thus, Niger Delta accounts for about 74.2% of the coastline of Nigeria. The Niger Delta Environmental Survey (NDES) (2007) reported that the region with it's enormous brackish water resources, is endowed with about 16 endemic fish species. However, these species are facing serious threats of extinction, with issues of pollution and climate change unarguably being critical causative factors in this phenomenon. several species of aquatic animals and is a favourable breeding sites for several migratory species (Awosika, 1995).

The predominant economic activities of most of the rural dwellers of the region had always been fishing, farming and trading, however with the recent environmental degradation in the region and climate change impact, a good number has been coerced by circumstances to abandon these their traditional occupations. The present situation notwithstanding, a considerable number of the region's rural population commonly fish or practice subsistence agriculture and supplement their diet and income with a wide variety of forest products. Education levels are below the national average and are particularly low for women.

From the preceding, it is obvious that the region is richly endowed with potentials for high fisheries yield and productivity. However, climate change amongst other environmental factors has posed a great challenge to fisheries resources in the Niger Delta region and it's enormous potential. Consequently, it is the consideration of this study to review and bring to fore, the major impacts of climate change on fisheries resources of the region and proffer effective recommendation to curb this challenge.

Causes of Climate Change in Niger Delta Region, Nigeria

Climate refers to the long-term regional or global average of temperature, humidity and rainfall patterns over seasons, years or decades. While the weather can change in just a few hours, climate changes over longer time frames. The climate of an area includes seasonal temperature and rainfall averages and wind patterns. Climate change is the significant variation of average weather conditions, becoming for example, warmer, wetter, or drier over several decades or longer. It is the longer-term trend that differentiates climate change from natural weather variability, there causing weather patterns in most cases to be less predictable.

Incidentally, the Niger Delta region incidentally in recent years has been inundated with several anthropogenic activities that has constantly exacerbated emission of greenhouse gases into it's atmosphere. Some of these activities include wanton massive oil spillages into it's terrestrial and aquatic environment, indiscriminate gas flaring, bush burning, illegal crude refining (locally called "kpo-fire") and other unregulated industrial emissions, majorly from the oil and gas industry. Thus, these activities have triggered a trail of factors that cause and or enhance climate change prevalence and impacts within the region. Some other factors implicated as causes of climate change in Niger Delta region are reviewed in the succeeding sub-headings;

Oil Spillage: The cases of oil spillage are prevalent across the entire Niger Delta Region. In many places such as Ogoni land in River State, Kilometers of previously forested lands are left bare due to oil spill. There are similar places in Bayelsa, Delta and Abia States, to mention but a few. Even in the creeks and Islands, there is vast destruction of mangrove forests when major oil spills occur, affecting the creeks. The implications of this extensive degradation of vegetation (deforestation) is that the capacity of the forest sequester carbon becomes highly reduced, thus leading higher concentration of carbon dioxide (CO_2) in the atmosphere. High Carbon dioxide concentration in the atmosphere alters the ozone layer in the atmosphere. This leads to a reduction of the in the amount of solar radiation reflected back to space, thus resulting in increased atmospheric temperatures.

Gas flaring and Emission: The continuous flaring of gas in many oil fields has pushed most of the hydrocarbon combustible constituents into the atmosphere. Emissions from vehicles and plants also constitute a major source of atmospheric pollution. Both emissions and gas flaring contribute immensely to the presence of carbon in the atmosphere and hence the raising of atmospheric temperature. The raised

atmospheric temperature increases the evaporation from the water bodies (rivers and Ocean) which ultimately leads to heavy rainfall in the region. Ighedosa (2019) reported that the Niger Delta is currently facing climate change induced temperature rise amongst others elements of whether; "meteorological evidence of variations in climatic elements (temperature, rain, and wind, sun, etc.) exists, with increased frequency of precipitation in all the ecological zones of the Niger Delta: Mangrove Forest and Coastal Vegetation; Freshwater swamp Forest; Lowland Rainforest; Derived Savannah and Montane Region. Climate variation increases the magnitude of vulnerability to climate change, increased risk and frequency of extreme flooding events."

Rainfall: The climate of the Niger Delta Region just as the rest of the country is influenced by the movement of the rain bearing south westerly winds from the sea and the dry north-east trade winds from the Sahara. Uyo, the capital of Akwa Ibom State, is one of the settlements within the region, with reliable autographic records of rainfall for a long time (Udosen, 2008). The mean annual rainfall at Uyo from 1977 to 2006 was recorded in 2443.3mm. This is an indication of heavy rainfall. In the coastal areas of the Niger Delta, the rainfall is even higher than at Uyo. With increased rainfall occasioned by global warming induced climate change, there has been consequential increase in flooding leading to the abnormally high incidence of flooding, such as the one of 2012 and 20202.

Oceanic Circulation: Elenwo and Akankali (2014) described the processes of Ocean circulation thus; "these cycles can vary in length from a little as ten years to many millions of years Ocean circulation is the large-scale movement of waters in the ocean basins. Seawater flows along the horizontal plane and in the vertical. Typical speeds of the horizontal flow or currents are 0.01 - 1.0 m/s; vertical speeds within the stratified ocean are much smaller, closer to 0.001 m/s. Variations in solar radiation received by earth; the amount of solar radiation that the earth receives, determines the climate and as the solar radiation changes, the climate changes alongside. The sun, which ultimately regulates all aspects of life on the planet earth, goes through periods of increased and decreased solar activity, which in turn affects how much energy the earth receives". The Niger Delta region has an extensive coastal corridor, so these cosmic interaction with oceanic water bodies resulting in oceanic circulation; plays a tremendous catalytic impact in the global warming and thus climate change incidences of the region in recent times.

Impact of Climate Change on Fisheries Resources in Niger Delta Region

1. **Mangrove Ecosystem Degradation:** Mangrove forests serve as nurseries and breeding grounds for both near-shore and off-shore marine species. Studies have shown that about 60% of the fishes in the Gulf of Guinea breed in the mangrove of the Niger Delta (Odiete, 1999). Fishes scatter their eggs in leaves of aquatic thick brushes and in sediments, guard eggs and juveniles in excavated nests. The shoreline along the Niger River is important in maintaining the temperature of the water because the slightest change in water temperature can be fatal to certain marine species of fish. Trees and shrubs provide shade and habitat for marine fish species, while reducing fluctuation in water temperature. With the disruption/destruction of the coastal ecosystem, loss of habitat and the climate getting warmer, the fish population of the waters in the region becomes adversely affected. Bolarinwa (2016), reported that coastal erosion and flooding smolder the fertilizing eggs and fry and juvenile stages of fishes, thus affecting recruitment into the population. This has been a major factor contributing to not just the reduction in fish

yield from both the artisanal and industrial capture fisheries of the region, but also in some cases the driving into extinction some highly vulnerable species capture.

2. **Climate change induced flooding impacts:** Ibim (2019) highlighted a catalogue of other impacts of climate change induced flooding impacts on Fisheries resources in Niger Delta region, which are reviewed as follows;

i. **Submergence of coastal /lowlands that serve as breeding sites:** When there is massive flooding incidence in the Niger Delta, such as the monumental ones that occurred in 2012 and 2022, it leads to the destruction and mortality of fish ova, fry, juveniles, as well as adult brooders, as they were easily washed ashore. Massive fish kills occurred and there was also a huge destruction of reproductive gametes (ova and sperm).

ii. **Introduction of seawater into fresh water sections of the river:** A sea level rise of one metre along the West Africa Coast will result in remarkable salination of river waters far inland. Areas that are hitherto known to have freshwater features will become brackish. This will cause higher salinities and increased or distorted ionic content of the water bodies, resulting in, osmotic in-balance or osmotic failure and death. This salination of the river can also result in deformation of fish gametes- fry, juveniles and adult reproductive systems and also, a change in the flora of the of the water body destroying habits and food organisms.

iii. **New Species Invasion**: Due to changes in the salinity of waters to brackish post-flooding, that were fresh pre-flooding, new species would naturally invade or colonize such water bodies, due to the changes in the ionic balance of the water. This artificial and drastic sudden change in the water chemistry is usually at the detriment of the fish species that had such waters as it's natural ecological habitat. This situation will inadvertently distort the ecological balance and the food chain of the affected aquatic habitat.

This new species invasion phenomenon has various implications; Predation pressure: Predation will be an issue as new species are introduced, Significant increases in the depth of such waters, resulting in possible colonization of larger predatory fish species, preying on the original species population therein, Inter/Intra specific competition: The incidental increase in fish population and diversity, results in competition for space, food, mating partners, amongst others, between and within species as the natural order of the habitats becomes distorted. altered and so on, Fishing Pressure: Fish exploitation by locals will be intensified as the search for food and income become intensified due to economic devastation of flooding in fishing communities, thus resulting in over fishing and fish yield decline, The fisheries of the area will be affected: Rise in sea level will also affect the fisheries as euryhaline species will tolerate the increased salinity while stenohaline species will migrate upstream and Habitat alteration will affect reproductive patterns and hence recruitment into the fisheries, thus resulting in economic dislocation of fishers from their traditional source of income.

iv. **Introduction of pollutants and wastes:** The composition of flood water is influenced by the features of the soil and human activities in the drainage area. Flood water sweeping over farmlands (especially in the north) will wash off residues of pesticides and herbicides. Flood water over industrial facilities will be contaminated by industrial effluents. Since Nigeria's topography, naturally influence the ultimate discharge of flood waters into the deltaic creeks and wetlands of the Niger Delta, a considerable amount of these contaminants often ends up in the Niger Delta. Ultimately, these pollutants become adsorbed or absorbed

onto or into the body tissues and fluids of the fishes as toxicants.

v. **Adverse Impacts on Natural Fish Food Organisms.** The toxicants about by introduced as a result of heightened flooding in the region due to climate change induced high rainfall intensity, may result in the water body attaining a level of toxicity that could result in an aquatic environment that becomes counterproductive for the thriving of natural fish food organisms.

vi. **Increase in Physical Aquatic Pollutants Impact:** Increased flooding because of climate change leads to greater accumulation of non-degradable pollutants, such as plastics (commonly referred as marine pollutants), since most of the water sheds in Nigeria are prone to indiscriminate waste disposal. This situation leads to these physical pollutants obstructing fishing activities, resulting in drudgery and low catch per unit effort for artisanal fishers of the Niger Delta region.

vii. **Shoreline Erosion and Sea Bottom Silting and Sea Depth Increase:** The land area/shoreline around the seas becomes eroded and shorelines become steep and deep. Flood water contains a large amount of suspended silt materials which are deposited downstream. The sea bottom will become silted by debris and soil wash-offs from surrounding land, which will eventually clog the gills of fishes, increases turbidity, reduce visibility and light penetration, and also increase harmful bacteria and micro-organisms growth. The deposited silt can also smother sessile bottom dwelling animals and the deposition process can alter the depth profile of the water column. Thus, leading to mortality and ultimate reduction in fish yield from capture fisheries within the region.

viii. **Ornamental Fisheries Degradation:** As a result of flooding regimes that are abnormally high resulting from climate change influence, a considerable value has been degraded from the Niger Delta ornamental fisheries resources, such as fins, skin colour, swimming patterns, breeding behavior etc. Most importantly the flooding impacts mortality on the ornamental fish stock and population of the region; leading to unique ornamental fisheries resource of the region being threatened with extinction.

3. **Potential Catch Reduction:** Climate change has affected fisheries through alterations in potential catch due to shifts in species range and decline in primary prey available to the species caused by acidification of the oceans from higher CO_2 levels, loss of coral reefs, because of ocean warming, and variations in ocean biogeochemistry, such as oxygen levels (Sumaila and William, 2010). The displacement of regular fish species to other regions could lead to disputes among international neighbors and could lead to increased implications for aquatic management across international water boundaries. Changes in species distributions also alter the distance fishermen need to travel to catch their traditional target species, sometimes crossing international sea boundaries. In the United Kingdom, at the North Sea, a large number of cold-water species (e.g., grey gurnard, cod, anglerfish, lemon sole and saithe) have deepened their residential water depth with an average of 5.5m per decade while some warm water species have moved to shallower depths, such as sole (7.6m per decade) and bib (6m per decade) (Grossmann, 2005). Similar situations are currently prevalent within the Niger Delta Region, leading to various undocumented, but obvious intra and inter regional fisheries resources exploitation conflict of interests amongst fishers.

4. **Changes in Fish Distribution:** Marine fisheries are an important food source, and therefore, changes in the total amount or geographic distribution of fish available for catch could

potentially affect food security (Cheung *et al*., 2009). The effects of changes in fish-stock distribution vary across latitudes. Some fish species will migrate north in search of habitats with optimal water temperature and thus potentially increasing fish harvest in higher latitudes. Thus, the climate change occasioned migration of fisheries resources, creates a distortion in the known pattern to the local fishers through which they track and encounter successful and profitable fishing activities.

5. **Increase in Water Salinity:** Adverse effect of sea level rise in the Niger Delta has increased salinity of both surface and underground water due to the intrusion of sea water which results to the death of aquatic plants and animals that cannot tolerate high salinity (Uyigue and Agho, 2007). The salination of the brackish waters in the region has been greatly affected by flooding and sea water intrusion leading to lose of indigenous aquatic species (Awosika, 1995). Sea water intrusion have impacted adversely on food security in the region, as it affects the coastal agriculture.

   Changes in water salinity have different effects depending on the tolerance level of the organisms and the nature of their ecosystem, whether freshwater, marine or estuarine. This kind of physico-chemical changes adversely affects the population of planktons and macro prey fish species by impairing their physiological processes. Some empirical studies illustrate that change in salinity has a negative impact on zooplankton population, particularly in freshwater ecosystems. Schallenberg *et al*., (2003) depict that zooplankton communities of low-lying, coastal, tidal lake and wetlands are adversely affected by small increases in salinity levels with a considerable negative impact on fishery.

6. **Migratory Behaviour:** The changing temperature may affect migratory behavior in fishes with earlier migration seen in western mackerel stocks, while flounders' migration from some south-west estuaries is delayed by warmer conditions (Grossmann, 2005). Thus, the incidental escape of cultured fishes during abnormal flooding as a result climate could result in a form of their accidental hybridization with wild stocks, which may result in undesirable species strains. High floods can also lead to the introduction of predators and disease into cages, leading to further loss of stock. If climate change increases the frequency or intensity of floods, fish farms and cages get more likely to get damaged, leading to greater economic losses. The abnormally high floods 2012 and 2022 in Niger Delta in particular, lead to the destruction and washing away into the wild from virtually all the earthen/concreted and cage aquaculture facilities into the wild. Changing rainfall patterns and water scarcity is impacting on river and lake fisheries and aquaculture production (Akankali and Elenwo, 2014). These phenomena, ultimately result in invasive species associated environmental and biodiversity challenges of fisheries resources in the Niger Delta region.

7. **Reduced Primary Production:** Changes in the temperature ranges will also change the location of areas with high primary productivity. These areas are important to marine mammals because primary producers are the food source of marine mammal prey or are the marine mammal prey themselves. Marine mammal distribution and abundance will be determined by the distribution and abundance of its prey.

   Migration of marine mammals may also be affected by the changes in primary productivity (Wikipedia, 2009). Primary productivity is affected by availability of nutrients in the water, which in turn depends

on freshwater run-off and ocean mixing as well as levels of light and temperature. In some areas reduced precipitation could lead to reduced run-off from land, starving wetlands and mangroves of nutrients and damaging local fisheries. The Niger Delta which is often hit by constant fluctuation in temperature ranges due to industrial activities is faced with the challenge of change in location of areas with primary productivity, since the entire food web is suspected to be highly altered adversely (Elenwo and Akankali, 2014).

8. **Dominance and Harmful Algal Bloom:** In other areas increased precipitation or increased extreme weather events, including flooding, will lead to excessive nutrient levels in rivers, lakes and coastal waters as sewage and fertilizer is washed into water bodies causing harmful algal blooms (HABs), also known as red tides (Reissig *et al*., 2006). For example, the 2012 flood which occurred in the Niger Delta would have washed enormous quantities of sewage and fertilizer into the water bodies in the region, leading to the emergence of harmful algal bloom. The change has the potential to affect the occurrence and severity of HABs because the growth, toxicity, and geographic distributions of HAB species (like all phytoplankton) are impacted by environmental variability (Epstein, 2000). Additionally, the susceptibility of shellfish, fish, and marine animals to the impacts of HABs can be exacerbated by other stressors that are also caused by climate changes. Recent data shows that unusual or unprecedented algal blooms have been linked to climate anomalies (Belgrano *et al.,* 1999). Similarly, climate changes in the Niger Delta have further worsened the effect of harmful algal bloom. Evidence also indicates that climate warming may benefit some species of harmful cyanobacteria (both freshwater and marine) by providing more optimal conditions for their growth (Pearl and Huisman, 2008).

In view of this, the Niger Delta with increased climate warming may provide more optimal condition for the growth of harmful cyanobacteria to the detriment of important aquatic fauna (Zhang *et al*., 2008). Increasing temperature and CO_2 either alone or in combination with nutrient availability may determine the growth and relative abundance of HAB species; thus, the Niger Delta with a steady increase of carbon resulting from industrial activities is usually faced with the growth and abundance of harmful algal bloom species.

9. Decreased pH and Increased Ocean Acidification:

Niger Delta aquatic ecosystems, absorb a large amount of carbon dioxide from the atmosphere, and cause an increase in carbon dioxide concentration and decrease its overall pH, increasing ocean acidification. This is because aquatic fauna does not need a basic nor acidic pH. The pH of the water should neither be basic nor acid, but it should be balanced, depending on the aquatic fauna; since aquatic fauna have different optimum pH requirement. The rising ocean acidity makes it more difficult for marine organisms such as shrimps, oysters, or corals to form their shells a process known as calcification. Many important animals, such as zooplankton, that forms the base of the marine food chain have calcium shells (Dupont and Thorndyke, 2009). Thus, the entire marine food web is being altered. As a result, the distribution, productivity, and species composition of global fish production is changing, generating complex and inter-related impacts on oceans, estuaries, coral reefs, mangroves and sea grass beds that provide habitats and nursery areas for fish.

Conclusion

Climate change has impacted moderately, though negatively on most aspects of fisheries resources in the Niger Delta region. These adverse impacts will keep altering conventional

fisheries resources and yield if unabated and will result in decreased quality and quantity of harvested fish, majorly from the natural sources. Climate change in the Niger Delta region of Nigeria, has led to decline of nursery for young fish, migration of fish, local extinctions of fish species, reduced primary production, dominance of harmful algal bloom as well as decreased pH and increased ocean acidification.

Recommendations

It is recommended that all factors known and particularly implicated in this paper as contributors to climate change impacts within the Niger Delta region, should be controlled and prevented where possible. Also, introduction of new water management reform and policy implementation programmes should be implemented by the relevant Authorities, coupled with adequate enforcement of relevant regulations. Industries in the Niger Delta region and crude oil exploration companies in particular, whose activities emit carbon, should reduce their level of carbon emission, by resorting to green energy sources, such as renewable (solar) and nuclear energy. When this is done, it will lower the greenhouse gases and by extension the atmospheric temperature of the region. Finally, National and sub-national governments in Nigeria, should develop high confidence prediction models of climate change perturbation on fish response in order to get accurate feedbacks, as well as adaptations measures to mitigate their impacts.

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Zero Carbon Emission Through Climate Smart Agriculture

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Abstract : *According to a report by the united nation, the global population is increasing at the rate of about one percent per year, from 7.95 billion in February 2022 to 9.7 billion in 2050 and an estimated 11 billion in 2100. This ever-growing population has led to a complex problem of food insecurity globally. In other to achieve the sustainable development goal (SDG #2), there is a need not just to increase food supply but avoid food wastage. As such, reducing environmental impact of Green House Gases (GHG) from Agriculture becomes a necessity in combating global warming. The agricultural sector is the world's second largest emitter of GHGs after the energy sector. Farmers in rural areas in the country. where farming activities are predominantly the major source of livelihood are faced with the challenge of GHG emission (in the form of methane (CH_4) and nitrous oxide (N_2O). Such Agricultural practices include: bush burning, cattle belching, deforestation, and energy use of CO_2 from agricultural operations (e.g., tractor fuel) or from inputs (e.g., fertilizer manufacture, composting and transport).The strategy to reduce the emission of these agricultural GHGs is likely to be through overall de-carbonization of energy generation, rather than reduction in agricultural activities. A change in both farming practices and demand for food offers big opportunities in GHG reduction. Farmers should be sensitized and encouraged to adopt improved crop management practices such as improved fertilizer management and conservation tillage. For the livestock sector, better management of grazing lands, such as rotational grazing and altering forage consumption. More so, restoration of degraded lands and cultivation on organic soils are important in reducing GHGs emissions. Consequently, reduction in food losses and wastage also play a significant role in mitigating GHG emissions. Recent research by the World Research institute shows that over 24 percent of calories produced for human consumption are lost or wasted in the food chain. Hence, a shift away from meat and beef consumption offers a good potential for reducing GHGs emission.In conclusion, government, voluntary groups, farmers and citizens should be sensitized to curb practices that produces carbon. Relevant authorities should urgently develop stringent policies to mitigate the emission of carbon into the environment.*

Keywords: *1. Zero carbon, 2. Smart agriculture, 3. Green house gases 4. Food security, 5. Climate change*

CITATION:

Ekpo, O., Victor, A., Nicholas, I., Bencourt, T., Ebek, V. (2023). Zero Carbon Emission Through Climate Smart Agriculture. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 308-313

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Introduction

The ever-growing increase in the world population has resulted in a significant increase in the demand for food. Production is struggling to keep up as crop yields level off in many parts of the world, ocean health declines, and natural resources including soils, water, and biodiversityare stretched dangerously thin. A 2020 report by Food and Agricultural Organization (FAO) (2021) found that between 720 and 811 million people from the global

population are hungry; this was attributed to the COVID-19 pandemic which greatly affected the agricultural sector. According to the reports, the world will need to produce approximately 70 percent food or more by 2050 to carter for the nutrient requirement of approximately 9 billion people, of which raises a problem of major concern to world leaders.

Agricultural production is greatly influenced by climatic factors. The challenge is intensified by agriculture's extreme vulnerability to climate change. Although the negative impact of climatic change on agricultural production has been greatly experienced by factors such as increase in temperature, low rainfall, weather variability, shifting agro-ecosystem boundaries, invasive crops and pests, and more frequent extreme weather events. This effect has also been experienced in the area of farm outputs which include reduction in crop yields, the nutritional quality of major cereals, and lowering livestock productivity. As such, there is a need to invest in adaptative measures that will maintain current yields and to achieve production and food quality increases to meet demand.

The problem also works in reverse. Agriculture is a major part of the climate problem. It currently generates 19–29% of total greenhouse gas (GHG) emissions. Without action, that percentage could rise substantially as other sectors reduce their emissions. Additionally, 1/3 of food produced globally is either lost or wasted. Addressing food loss and waste is critical to helping meet climate goals and reduce stress on the environment.

Relationship between Smart Agriculture and Zero Carbon Emission

Small holder farming dominates the agricultural landscape in Sub-Saharan Africa (SSA) and mostly operates in less than 2 hectares in total landholdings (Lowder *et al*., 2014) in most areas of Nigeria, this traditional farming method has been challenged by increasing demand for food and climate change (Jagtap, 2007). While these little agriculture realities provide food security and income for many households, it faces the challenge of increasing production to ensure food security for the growing population alongside with preserving its environment and natural resource base (FAO, 2013). These goals are further exacerbated by climate change and variability interacting with pre-existing socio-economic, cultural and political inequalities to shape vulnerability, yet, population growth and increasing consumption of high calorie and meat-intensive diets are expected to double human food demand by 2050 (Tilman *et al*., 2011). Small holder farmers will play a critical role in meeting this target. Increasing productivity to achieve food security is expected to entail a significant escalation in emissions from agricultural sector especially in developing countries (Long*et al.,* 2016).

Ways in attaining Climate Smart Agriculture

Climate-smart agriculture (CSA) is an integrated approach to managing landscapes cropland, livestock, forests and fisheries that addresses the interlinked challenges of food security and accelerating climate change. CSA aims to simultaneously achieve three outcomes:

1. Increased productivity: Produce more and better food to improve nutrition security and boost incomes, especially of 75 percent of the world's poor who live in rural areas and mainly rely on agriculture for their livelihoods. It is therefore believed that when food security is attained, farmers (especially resource poor residing in rural areas) will reduce the utilization of carbon emitting practices such as bush burning, deforestation etc.
2. Enhanced resilience: Reduce vulnerability to drought, pests, diseases and other climate-related risks and shocks; and improve capacity to adapt and grow in the face of longer-term stresses like shortened seasons and erratic weather patterns.
3. Reduced emissions: Pursue lower emissions for each calorie or kilo of food produced,

avoid deforestation from agriculture and identify ways to absorb carbon out of the atmosphere.

The use of energy has been a major driver of economic and social development. This has enabled the human race to lead some form of comfortable and enjoyable life. The growth in technological development is a result of the abundance and use of fossil fuels; that indeed fostered the era of industrial revolution. Nonetheless, the widespread consumption of fossil fuels has led to the release of excess greenhouses gases (GHGs) and other toxic elements into the environment (Eyre and Killip 2019). These GHGs are capable of trapping more heat in the atmosphere with a consequential negative impact on the climate, such as global temperature rise. This occurrence is known as climate change. The higher the production of GHGs, the higher the degree of earth warming, increasing the incidence of such adverse impacts as bush fires, storms, heat-waves, flood, etc. Cumulative emission of anthropogenic CO_2 has been identified as the major contributor to post-industrial anthropogenic temperature increase (Friends of the Earth 2018)

Globally, the demand for energy is projected to increase significantly over this century. However, to stabilize the global mean temperature, the net emissions of carbon dioxide (CO_2) from human activities including not only energy and industrial production, but also land use and agriculture must approach zero (Abraham 2019).The necessity to limit the emission of CO2andother GHGs has become more pressing than ever as reliance on fossil fuels to meet the growing global demand for energy continues. While the energy demand in industrialized countries will remain high to sustain their development, demand is growing fast in countries in transition due to their growing population and an increasing standard of living (Glynn *et al*., 2019; Abraham 2019). It is very crucial to tackle ecological concerns alongside climate issues. According to reports by the Intergovernmental Panel on Climate Change (IPCC, 2021) has indicated that to achieve zero global warming on earth, the total carbon emission must be reduced to zero. Although the report stated that the process may take several years (within 20-30 years) for climate to stabilize. The report stressed that any scenario that does not entail the global reduction of emission to zero is not capable of addressing the challenge of a changing climate.

Achieving net zero emission by 2050 requires actions in adopting low carbon emission path-ways that enhance the widespread deployment of clean energy sources to replace fossil fuels, as well as the reduction of total energy demand through higher energy efficiency and changes in consumer behaviour. Massive production of carbon-neutral and energy-dense liquid fuels may be critical towards the provision of energy that is needed to drive the stationery and transportation energy production sectors, such fuels include hydrogen and ammonia, bio-fuels, synthetic hydrocarbons, and direct solar fuels (Glynn *et al*., 2019).To achieve the goal of net zero emission, there has to be a shift in policy orientation at all levels, technological development must be tailored to international climate goals, corporate and individual behaviour has to change to protect the environment (Levin and Davis 2019). However, net zero emission can be achieved mainly in three ways:

1. Emission offsetting: this refers to the reduction or avoidance of emission of CO_2 or other GHGs in one sector to compensate for emission made somewhere else. This can be achieved by investment in energy efficiency, renewable energy or other low-emission technology. The emission trading system (ETS) of the European Union is a good example of emission offsetting system. Emission offsets are measured in tons of carbon dioxide equivalent (CO_2e). Emission offsetting operates in two markets levels. In

the higher compliance market, governments, companies, and other entities can purchase emission offsets to enable them to comply with their emission limits. In the lower voluntary compliance market, governments, companies, and individuals can buy emission offsets to compensate for their emission from transportation, electricity, and other emission contributions (Revkin, 2007).

2. Carbon removal/sequestration: this refers to the removal and long-term storage of atmospheric CO_2 to mitigate the effect of global warming. Carbon sequestration occurs both naturally and through artificial processes Net Zero Emission, Global fossil fuels and industrial emissions (Davis *et al.,*2018). CO_2 is removed from the atmosphere naturally through biological, chemical, and physical processes and stored primarily in green plants and trees, in soils as organic debris, in geologic formations that are inactive for indefinite period, and the oceans (Selin, 2020). This is the process with which nature has achieved balance in atmospheric CO2in a way that optimally supports life. However, several artificial processes have been developed to achieve similar purpose such as large-scale artificial sequestration of industrially CO_2 emissions through subsurface saline aquifers, reservoirs, or direct air capture (Sedjo and Sohngen, 2012). It has been projected that through improved land use practices, about 600 mega-tons of CO_2 equivalent ($MtCO_2e$) per year of GHG can be captured and removed from the atmosphere, which amounts to about 10% of1990 emissions (Selin, 2020).
3. Emission reduction: this refers to the minimization of the amount of $CO_2$and other GHGs emissions through adjusting industrial, agricultural, and other processes, for example, the use of renewable energy sources (e.g., solar and wind energy) and energy efficient processes to reduce emissions. Though both fossil fuel and non-fossil fuel-based energy sources produce emissions, no fossil fuel-based energy sources produce significantly low emissions (Sedjo and Sohngen 2012).

Challenges in attaining Zero Carbon Emission

The major factors hindering the attainment of net zero emission include the high capital of the existing technologies, poor energy efficiencies, and people's attitude to the use of energy. To therefore achieve the full de-carbonization of the environment, there is a need to enhance technological cost reductions via research and innovation. Other factors are:

(a) Most carbon neutral fuels have considerably lower gravimetric and volumetric energy densities than the conventional fossil fuels: this implies that most carbon neutral or synthetic fuels such as hydrogen fuel and bio-fuels cannot store as much energy per unit volume or mass as the conventional fossil fuels. Thus, while they are likely to be more expensive, most synthetic fuels produced from renewable sources have lower energy content than fossil fuels (Pearson *et al*., 2012). Therefore, carbon neutral fuels have limited utilization efficiency and their suitability is dependent on the energy demands of an infrastructure or a journey.

(b) Stiff competition between food security and bio-energy production: though the development of bio-energy has received tremendous acceptance globally in the quest for greener environment, the rate of bio-energy development has also begun to brew concerns for its nexus with food security. This is because most of the food crops such as cassava, soybean, groundnut, and sugarcane among other energy-rich crop which form the basic food crops especially in most countries also constitute feed stocks for bio-fuel production. (Matemilola *et al*., 2019).

(c) Lack of policies that target long-term systemic changes in the energy sector: energy consumption across the industrial, transport, residential, and commercial sectors are responsible for the greater share of global emissions. Emission of GHG imposes costs on society; thus, an emission pricing system could be an important tool in the bid to de-carbonize the energy sector. However, carbon pricing policies have so far seemed very difficult to enact and implement in many developed and developing countries. Certification and performance measurement policies are other essential tools for de-carbonization but implementation in the energy sector have been torrid (Zogopoulos, 2019).

(d) Large scale deforestation and ineffective land use: deforestation accounts for about 15% of global carbon emissions, making it a key driver of climate change. The need to eliminate deforestation can therefore not be overemphasized. In their pursuit of carbon neutrality at the Bonn climate summit, 2017, 27 countries including Brazil and Indonesia committed to increase the use of wood products for energy generation with the plan to plant new saplings that could reabsorb the CO_2emitted by fully grown burned trees within years to decades. Scholars have however argued that this effort will create huge demand for wood and increase deforestation that could pose unimageable grave threat to the world's carbon sink (Neslen, 2018).

Conclusion

To avert a dangerous level of global warming, it has become inevitable to reverse the global GHG emission trend and ensure it reaches net zero by mid-century. Though energy is the primary driver of economic growth, most of the global emissions arise from energy use. It is therefore imperative that the global energy system is de-carbonized. In the light of the growing global emission pattern, world leaders and governments should pursue efforts to keep the global average temperature increase well below 2 degrees Celsius. In order to achieve these, governments, corporate organizations, and individuals have a key role to play which includes removal of carbon from the atmosphere via afforestation/reforestation, enhanced mineral weathering, or direct capture of CO_2 from the air. Emission trading as well as emission reduction through efficient use of energy and use of renewable energy sources represent some of the core approaches.

Recommendations

A change in both farming practices and demand for food offers big opportunities in GHG reduction. Farmers should be sensitized and encouraged to adopt improved crop management practices such as improved fertilizer management and conservation tillage. For the livestock sector, better management of grazing lands, such as by rotational grazing and altering forage consumption. More so, restoration of degraded lands and cultivation on organic soils are important in reducing GHGs emissions.

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Future Climate Change and Development In Northeastern Nigeria

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Abstract: *Climate change is known to affect almost of aspects of human life, often in a negative way. Most of the effects depend on the level of exposure and vulnerability of the people involved, which are to the larger extent determined by the environmental, economic and socio-demographic conditions of the people. This study examines the effects of future climate change on five Sustainable Development Goals (SDGs) in the Northeast Zone of Nigeria. This zone consists of Adamawa, Bauchi, Borno, Gombe, Taraba and Yobe states. Observed (1901-2020) and projected (2021-2100) rainfall and temperature data for each of the states were downloaded from the World Bank Climate Change Knowledge Portal. From these data, annual averages for Adamawa/Taraba, Bauchi/Gombe and Borno/Yobe were computed and subjected to time series analysis. Results show highly variable historical rainfall condition and a sustained increase in temperature from the mid-1970s to present. Projected (SSP2-4.5 and SSP5-8.5) scenarios indicate higher increases in rainfall and temperature than SSP1-1.9 scenario. These changes portend direct and indirect derailment of development efforts in the area as they are bound to decelerate the achievement of the selected SDGs. Climate change should therefore be taken as an important challenge to development in the area. It is recommended that climate change should be adequately observed, levels of exposure and vulnerability of the people appropriately determined and mapped and adaptation measures adequately taken in the study area.*

Keywords: Climate change, Climate scenario, CMIP6, Global warming, North-eastern Nigeria, Standardized Precipitation Index

CITATION:

Usman, S. U., Umar, N., Khalil, M. S. and Abdulhamed, A. I. (2023). Future Climate Change and Development in Northeastern Nigeria. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Professor Nyaudoh U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp.298- 307

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Introduction

Sustained increases in the emission of greenhouse gases (GHGs) through human activities such as industrial and agricultural productions, power generation and transport are causing significant changes in the Earth's atmospheric composition. Consequently, this has been leading to an increase in the build-up of heat, especially in the lower atmosphere, a process widely known as global warming (GW). A progressive increase in GW is affecting certain processes in the global climate system. These include enhancement of evaporation rates from water bodies and land masses, increasing the atmospheric water holding capacity and altering the global hydrological cycle patterns (Forster *et al*., 2021; Bigg & Hanna, 2016). Consequently, an unprecedented and widespread increase in climate extremes such as droughts, floods, heat

waves and hurricanes as well as an increase in climate variability and shifts in climates are being experienced globally (Sereviratne *et al*., 2021). These are cumulatively referred to as climate change.

Paris Agreement of 2015 is one of the global efforts of restricting GW to at least 1.5^{o}C relative to the pre-industrial level through tremendous reduction of GHGs emissions. However, the half-hearted commitment of the major GHGs emitting countries toward their emission obligations has been pushing the goals of the Agreement further out of reach. This attitude and slow adaptation to the ongoing as well as the future effects of climate change on national, regional and global scales, have been described as too inadequate (United Nations Environment Programme [UNEP], 2022). These imply increased exposure of vulnerable countries to adverse effects of climate change as well as continuous erosion of their adaptive capabilities. According to the United Nations Office for Disaster Risk Reduction (UNDRR) 2019 report, climate change is one of the drivers of disasters and development losses, which affect the security and well-being of countries (UNDRR, 2019). These and other facts prompted many researchers to investigate the effects of climate change on the Sustainable Development Goals (SDGs) of the United Nations.

SDGs are a set of 17 goals aimed at being achieved by all the United Nations member countries by the year 2030 (United Nations General Assembly, 2015). World Meteorological Organisation [WMO] (2021) elucidated the ways in which climate change affects SDGs. Several studies reported how future climate change will adversely affect all or some of the SDGs at global, African and Nigerian levels. For instance, how it affects the African economy (Africa Development Bank, 2019), human and livestock health (African Development Fund, 2011; International Centre for Tropical Agriculture, 2014), reduction of GDP in some Sahelian countries (World Bank, 2022) as well as how it effects crop production in Nigeria (Shiru *et al*., 2020; Federal Ministry of Education and Research, 2021). Effect of climate change-related increase in flooding on some SDGs in Nigeria was investigated by (Echendu, 2020).

The specific objectives of this study include examining the effects of future climate change on five SDGs in the Northeast zone of Nigeria, which are; (i) No poverty (ii) Zero hunger (iii) Good health and well-being (iv) Quality education and (v) Clean water and sanitation. Results of this study could be useful for different aspects of planning.

Methodology

The Study Area

Northeast Zone of Nigeria is located between latitude 6^{o}30'42.5''N to 13^{o}43'14.5''N and longitude 8^{o}44'57.44''E to 14^{o}40'52.7''E (Fig. 1). It shares border with Niger Republic to the north, Chad and Cameroun Republics to the northeast and east and, to the west by the Nigerian states of Benue, Nasarawa, Plateau, Kaduna, Kano and Jigawa. Total land area of the zone is 280,422km^2 representing 30.8% of the country's land area. The area cuts across five ecological zones namely; Sahel, Sudan, Northern Guinea, Southern Guinea and Derived savanna (Federal Republic of Nigeria, 2018). The 2019 projected population indicates that the area has a total population of 27,365,835 representing 13.6% of Nigeria's population (National Bureau of Statistics [NBS], 2020). Relief of the area ranges from just above 280m around the Lake Chad to over 1,800m on the Mambilla Plateau. The area has a tropical continental wet and dry type of climate, where the length of the wet season increases from north to south. The total annual rainfall also increases from north (about 427mm) to south (1,666m) (Federal Ministry of Water Resources and Japanese International Cooperation Agency, 2014). The major occupations of the majority of the populace are crop and livestock production and fishing. The

area is home to Lake Chad, which is very important for fishing, crop and livestock production and navigation among the countries that share it; Cameroun, Chad, Niger and Nigeria. Mambilla Plateau, an important geomorphological feature is also found in the area, which is very important for the production of certain crops such as coffee and tea as well as livestock production.

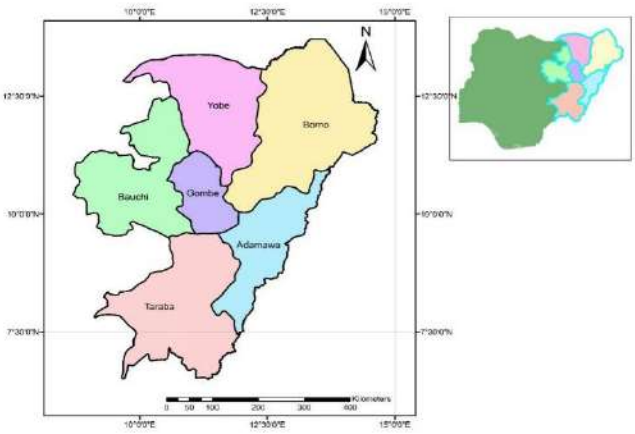

Fig. 1: Map of Northeast Zone of Nigeria

Methods

The data used in this study are observed rainfall and mean temperature data for the period 1901 to 2020 and projected rainfall and mean temperature data for 2021 to 2100 for all the states in the study area. The observed data were generated by the Climate Research Unit of the University of East Anglia while the projected data were generated by the World Climate Research Programme's Coupled Model Intercomparison Project Phase 6 (CMIP6), which comprise Shared Socioeconomic Pathways (SSPs) 1-1.9, 2-4.5 5-8.5 (representing low to very high CO_2 emission scenarios) involving 32 ensembles. Both the observed and projected data were downloaded from the World Bank Group's Climate Change Knowledge Portal (https://climateknowledgeportal.worldbank.org /download-data). SSP1-1.9, SSP2-4.5 and SSP5-8.5 were used in this study. From these, averages for Adamawa/Taraba, Bauchi/Gombe and Borno/Yobe were computed and Time Series Analysis is used in portraying the rainfall and temperature conditions of the study period.

Results

Observed and projected rainfall conditions:

Rainfall condition during the observed (1901 to 2020) and projected (2021 to 2100) periods are presented in Fig. 2. The observed period is characterised by high inter-annual and decadal rainfall variability in all the states. The period from 1901 to the mid-1960s is comparatively wetter than the succeeding one, especially from the late 1960s to late 1990s. The latter period is characterised by frequent and severe droughts. An increase in annual rainfall amounts started to be experienced throughout the Northeast from the early 2000s to present. In the case of the projected period, all the three scenarios portend an increase in annual rainfall amounts in Adamawa and Taraba states. For the rest of the study area, SSP1-1.9 indicates a decrease in rainfall amounts while SSP2-4.5 and SSP5-8.5 indicate an increase. Variations among the scenarios mostly become more apparent around late 2040s and continue to increase up to the end of this century.

Observed and projected temperature conditions

The observed (1901 to 2020) and projected (2021 to 2100) mean temperature conditions are presented in Fig. 3. From 1901 to 1923 the area experienced low mean annual temperatures characterized by low inter-annual variability while from 1924 to 1943 high mean annual temperatures with the highest inter-annual variability were experienced. This period was followed by the one with comparatively low mean temperatures, which lasted throughout the area until early 1970s. The mid-1970s marked the beginning of a steady increase in the mean temperature, which spanned the remaining historical period. The projected

temperatures indicate a steady increasing trend, especially the SSP2-4.5 and SSP5-8.5 scenarios. These increases range from 0.033°C (SSP2-4.5) and 0.076°C (SSP5-8.5) per year in Adamawa/Taraba to 0.034°C (SSP2-4.5) and 0.079°C (SSP5-8.5) per year in Borno/Yobe.

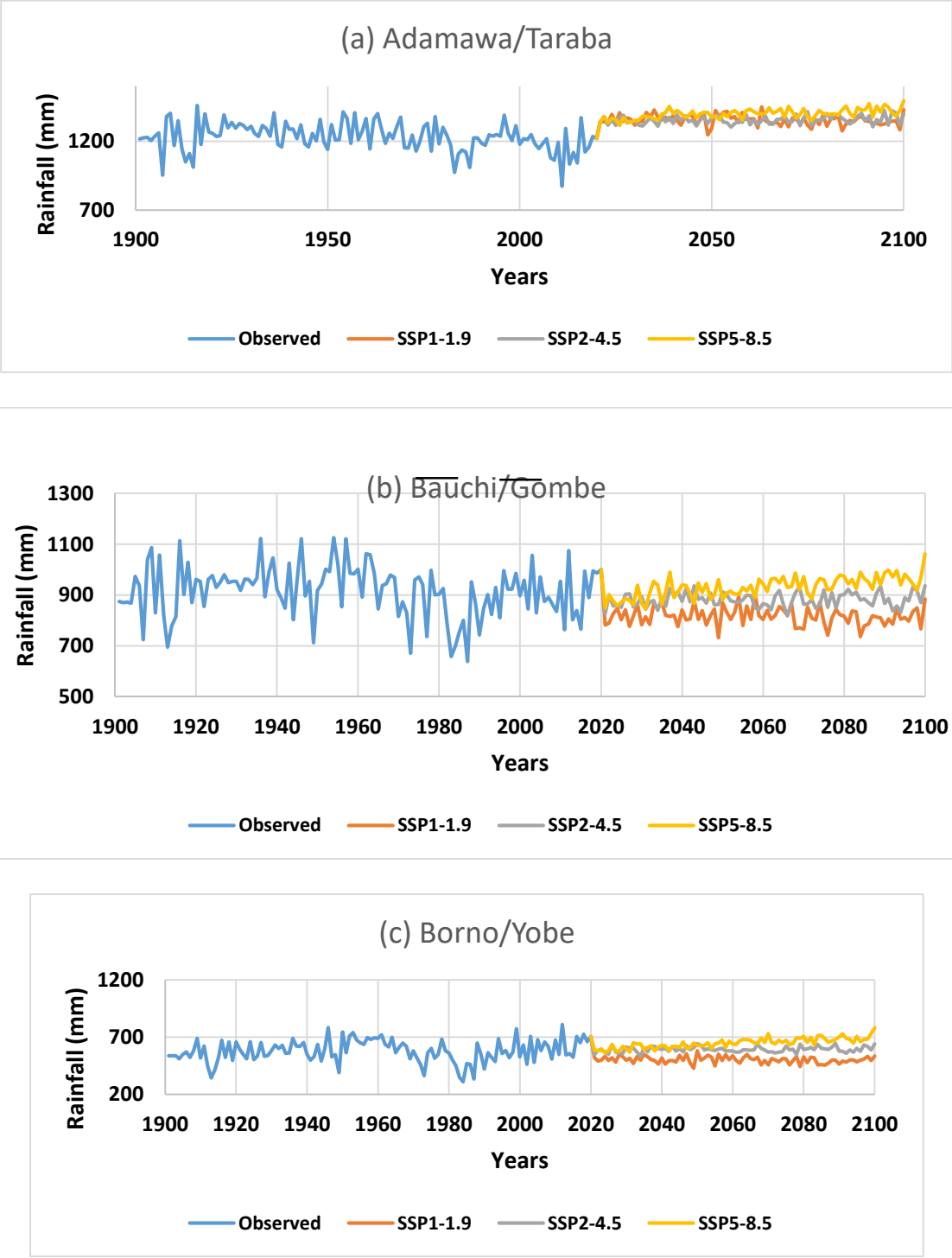

Fig. 2: Observed and Projected Rainfall Condition in the Study Area

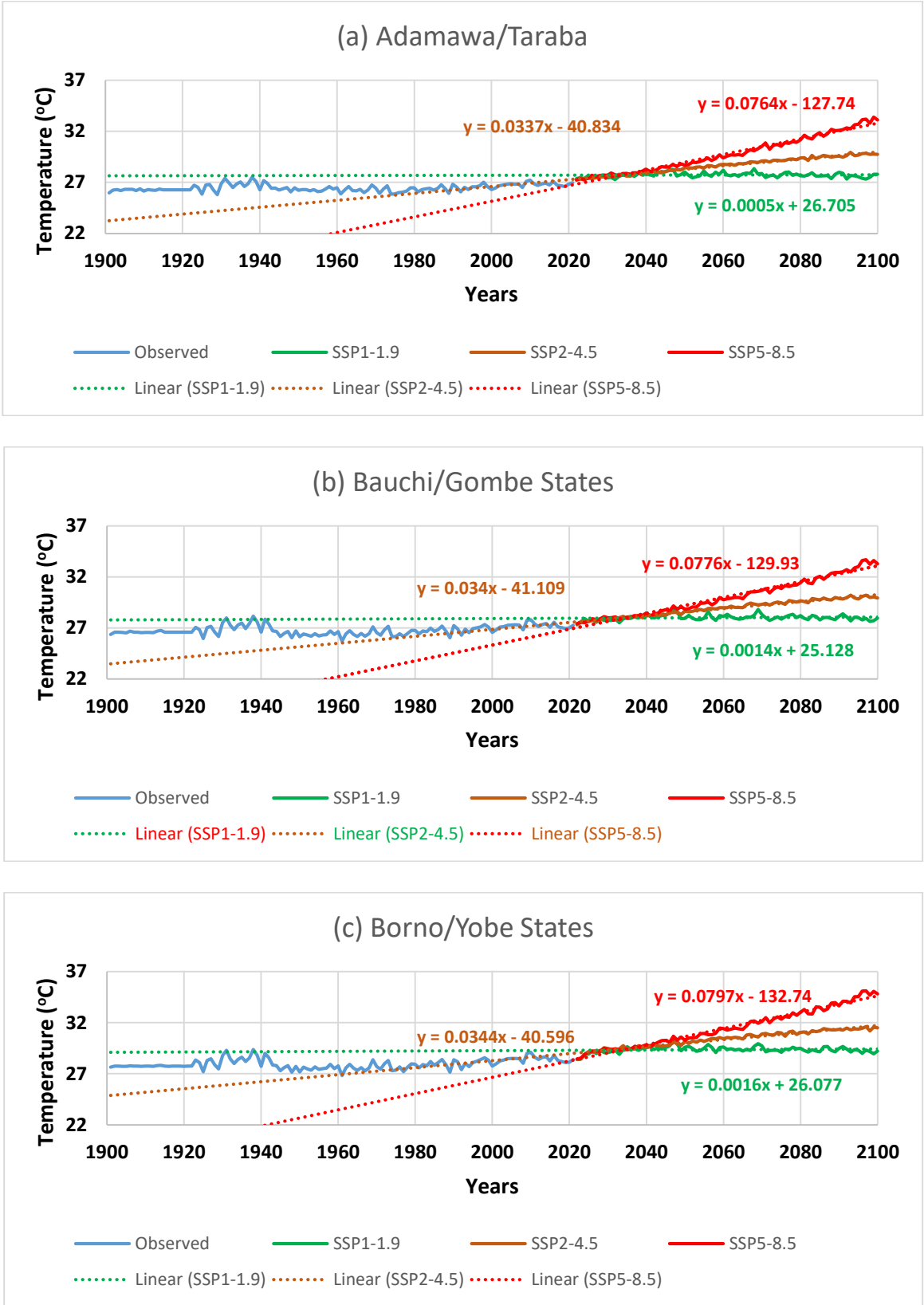

Fig. 3: Observed and Projected Temperature Conditions in the Study Area

Effects of projected rainfall and temperature on Sustainable Development Goals

1. SDG Number 1: No Poverty

Northeast is one of the geopolitical zones with the highest number of people who are multi-dimensionally poor in the country. By 2020, the multidimensional poverty index (MPI) in the area ranges from 0.283 (Adamawa) to 0.380 (Gombe) (National Bureau of Statistics, 2022). Adverse effects of projected climate change scenarios are likely to push more people into poverty and further impoverish those that are already poor, for the following reasons. One, the population is predominantly agrarian, ranging from 70% in Borno State (Food and Agriculture Organisation and International Crop Research Institute for the Semi-Arid Tropics, 2019) to 75% in Taraba (Taraba State Government, 2022), which implies high exposure to climate shocks. In Nigeria, research has shown that climate vagaries such as droughts and floods result in a significant escalation of household poverty, especially in communities that are heavily dependent on agriculture (Eze, 2018; Africa Development Bank, 2019). Two, the widespread multidimensional poverty limits the capability of the populace to absorb the climate shocks. Some of these shocks include increased frequency of droughts and floods, reduction of crop and livestock productivity due to the increase in temperature as well as erosion or loss of sources of the people's livelihood and an increase in competition for resources. For example, the shrinking of Lake Chad, which is largely attributed to climate change pushed millions of people out of fishing business (De Young *et al*., 2012). It was reported that by 1990s, more than 54% of the fishing families have changed to farming (Sarch, 1996). These and widespread unemployment among the youths may continue triggering violence in the area. Therefore, future changes in the climate will make eliminating poverty by the year 2030 a near impossible task.

2 – SDG Number 2: Zero Hunger

Climate change involving a decrease or an increase in rainfall, especially when accompanied by an increase in temperature and desertification is bound to undermine all the pillars of food security in the Northeast of Nigeria. Usman *et al* (2022) discussed how climate change has been and will be adversely affecting all the pillars of food security in the area in the following ways: Food availability is affected through a decrease in crop yield and livestock productivity or even loss of crops and livestock as a result of floods, desertification and an increase in atmospheric carbon dioxide. Food accessibility and stability are affected through destruction of roads and bridges by floods, an increase in food prices beyond the purchasing power of many and a reduction in the accessibility of food markets as a result of climate change-relate conflicts. Food utilisation is affected through an increase in climate change-related disease burden. Therefore, given the projected changes in climate and the adverse effects of the changes on food security in the study area, it is quite unlikely that hunger will be eliminated by the year 2030 or even beyond.

3. ***SDG Number 3:*** *Good Health and Well-being*

The projected increase in rainfall amount is bound to result in an increase in the frequency and intensity of floods in the Northeast zone. Caretta *et al* (2022) projected an increase in river flow by 78-85% in Nigeria due to an increase in rainfall amounts. This portends an increase in urban flash floods as well as river floods. It also indicates an increase in the necessity to release excess water from reservoirs within and upstream of the area. Such reservoirs include Lagdo (Cameroon), Kiri Adamawa), Dadin Kowa (Gombe), Kashimbilla (Taraba) and Tiga (Kano). Flood waters from these dams contaminate

sources of water leading to an increase in water-borne and water-related vector borne diseases in the area. For instance, the 2022 floods resulted in 7,700 cases of cholera, with 324 deaths in Adamawa, Borno and Yobe states (Office for the Coordination of Humanitarian Affairs, 2022). In the same vein, the projected increase in temperature is likely to lead to an increase in heat-related diseases such as cerebrospinal meningitis, measles and cardiovascular diseases as well as heat stress, thermal discomfort and other health problems related to elevated temperatures. These will be more among heat-vulnerable groups like infants, the elderly and pregnant women.

4. *SDG Number 4: Quality Education*

The projected changes in climate will adversely affect education both directly and indirectly in the area. The direct effects include significant reduction in school attendance due to an increase in floods. More communities will be displaced and more schools will be used as temporary shelter for the displaced populations. High temperatures will also affect teaching and learning processes through increased thermal discomfort among both the pupils/students and teachers. The indirect effects are through an increase in climate change-related violent conflicts (due to an increase in competition for resources), poverty and malnutrition (due to an increase in food insecurity). Currently, Northeast zone is one of the areas with the highest rate of malnutrition featured as severe anaemia in children (<7.0 g/dl of haemoglobin) in the country. It ranges from 3.1 (Adamawa and Taraba) to 6.0 (Bauchi) (National Population Commission and ICF, 2019). Malnutrition is one of the major impediments to achieving the goal of providing quality education anywhere in the world. This is because research has established that it limits the ability of individuals to realise their cognitive potentials (Ecker & Breisinger, 2012). Therefore, with the projected climate change obtained by this study and others, it is not likely that this SDG goal will be achieved in the foreseeable future in the study area.

5. *SDG Number 6: Clean Water and Sanitation*

The results of projected rainfall conditions of this study, especially the SSP2-4.5 and SSP5-8.5 scenarios may indicate a boost to water resources in the study area through increased recharge of both the surface and groundwater. It may also imply an increase in contamination of water sources through increased floods and surface runoff. This is quite possible when viewed against the backdrop of prevalent lack of sanitary facilities among households in the study area, which ranges from 47% in Borno State to 86% in Adamawa State (National Bureau of Statistics, 2022). Lack of access to clean drinking water among households is already a problem being experienced in the area, which ranges from 9% in Borno State to 86% in Taraba State (National Bureau of Statistics, 2022). The situation is likely to be pathetic when viewed against future projections of water demand in the area. According to Federal Republic of Nigeria and Japanese International Cooperation Agency (2014), by 2030, climate change will result in an increase in water demand in the area ranging from 1% in Taraba State to 94% in Borno State. Having considered all these, it seems obvious that future changes in the climate of the study area as projected in this study are likely to prevent the full achievement of SDG number 6 in the area.

Conclusion and recommendations

Results of this study indicate highly variable rainfall condition and an increasing temperature condition during the historical period (1901 to 2020). For the projected period, all the temperature scenarios indicate increasing trends of various magnitude while increasing and decreasing trends are shown by the rainfall scenarios. These changes are likely to have a negative impact on development in the area. They will decelerate or even prevent the eradication of poverty and hunger and increase

disease and malnutrition burdens, which will hamper the achievement of good health and well-being among the populace. School attendance and school activities will be disrupted thus, limiting the provision of quality education within the stipulated period. Demand for water will be increased by demographic and climatic factors while the sources will be progressively contaminated through increased flooding and unsanitary practices, which will be detrimental to provision of clean water and sanitation.

This study recommends adequate monitoring of climate change in the area with the aim to determine its trend in order to enable its reliable modelling. Climate-smart agriculture should be widely adopted as it will boost the predominantly rural agrarian economy, which will help in tackling the problem of adverse effects of climate change on hunger, poverty, health and education. Effective and timely early warning systems for climate extreme events such as floods, droughts and heat waves should be developed to reduce their adverse effects on development. Climate change resilient public water supply systems should be widely provided to reduce the negative effects of climate change on clean water supply and sanitation.

Conflict of interest: The authors declare that there is no conflict of interest

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Climate Change And Future Development Challenges In Nigeria

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Abstract : *The human population grows on daily basis, with extension of its technological footprint on the planet. The increasing population and other new species and ecological perturbations have altered the landscape leading to potentially irrevocable changes in biotic structure. Accelerated perturbation in global ecosystems can initiate events that can link to climate change, loss of biodiversity, emerging infectious diseases and other negative impacts. Climate change has caused ecological agitations, which cause geographical shifts, and alteration in the dynamics of parasite transmission, increasing the potential for host switching. In addition to having direct effects on individuals, climate change can alter the entire ecosystem habitats (including urban habitats), bringing various sectors to a halt. To overcome development challenges in future, Nigeria needs multilateral partnerships, education on mitigation of the impacts of climate change as well as stakeholder engagements involving policy makers, and private sector players including entrepreneurs, agricultural firms, media and identified vulnerable groups.*

Keywords: greenhouse gases, Climate Change, Ecosystem, Development and Nigeria.

CITATION:

Ebong, N. E. and Imikkan, A. M. (2023). Climate Change and Future Development Challenges in Nigeria. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp.292- 297

Introduction

Climate Change refers to the rise in average surface temperature on earth. It is a naturally occurring event, but human activities have significantly contributed to changes in atmospheric conditions, resulting in an accelerated change in this process, and the current precarious state (Stocker *et al*., 2013). Climate change is increasingly threatening human population with its great impact on the health and security of humans. These security concerns linked with climate change include; impacts on food, water and energy supplies. Global climate experts agree that anthropogenic activities have significantly contributed to the increasing concentration of atmospheric greenhouse gases and destruction of ecosystems (Solomon *et al.,* 2009). Climate change directly causes increase in temperature and affects weather patterns, which indirectly can change spatial patterns of disease vectors and human populations (Genchi *et al.*, 2011). Climate change in Nigeria affects various sectors (such as agriculture, forestry, fishery, etc.) that depend on climatic conditions, such as rainfall, sunshine, etc.

Natural hazards such as (volcanic eruption) are primarily seen as the reasons for climate change; scientists have however identified human activities as the key factor promoting climate changes. Human activities promoting climate change include

Genotype	N	Weeks 0	1	2	3	4	5	6	7	8
M x M	50	1.45±0.01^{a}	2.87±0.52^{a}	3.48±0.05^{a}	4.64±0.07^{a}	5.79±0.08^{a}	7.02±0.10^{a}	8.03±0.12^{a}	9.65±0.18^{a}	10.83±0.20^{a}
N x N	50	0.96±0.01^{c}	1.67±0.03^{c}	2.33±0.05^{e}	2.94±0.07^{f}	3.62±0.08^{g}	4.47±0.11^{f}	5.34±0.13^{f}	6.06±0.14^{g}	7.10±0.12^{g}
Fz x Fz	46	1.18±0.18^{b}	2.01±0.03^{bc}	2.84±0.05^{c}	3.50±0.06^{d}	4.25±0.08^{e}	4.86±0.08^{e}	5.57±0.12^{d}	6.42±0.10^{e}	7.33±0.17^{e}
Nk x Nk	48	1.05±0.02^{bc}	1.94±0.03^{bc}	2.60±0.05^{d}	3.24±0.07^{e}	3.95±0.10^{f}	4.55±0.12^{f}	5.46±0.08^{e}	6.36±0.16^{f}	7.22±0.10^{f}
M x N	49	1.16±0.01^{b}	2.04±0.02^{bc}	2.88±0.06^{c}	3.70±0.07^{cd}	4.57±0.09^{c}	5.36±0.10^{cd}	6.50±0.09^{cd}	7.10±0.13^{d}	8.23±0.10^{d}
M x Fz	46	1.40±0.02^{a}	2.02±0.04^{bc}	2.90±0.07^{c}	3.75±0.07^{c}	4.56±0.09^{cd}	5.50±0.11^{c}	6.57±0.08^{c}	7.45±0.08^{c}	8.59±0.13^{c}
M x Nk	50	1.20±0.01^{b}	2.31±0.02^{b}	3.13±0.04^{b}	3.91±0.04^{b}	4.79±0.07^{b}	5.71±0.07^{b}	6.65±0.11^{b}	7.91±0.08^{b}	8.93±0.15^{b}

Sources of Climate Change in Nigeria

- **Discharge of greenhouse gases from vehicles and industries**: Some vehicles emit greenhouse gases such as sulphur dioxide and carbon monoxide from their exhaust. Industrial machines also emit gases into the environment.
- **Burning of hydrocarbon products:** This releases carbon dioxide and other gases into the atmosphere.
- **Deforestation:** This refers to cutting down trees, usually for agriculture. Trees form a protective barrier against the heat from the sun and cutting them down has a negative effect on the environment. Between 2002 and 2020, Nigeria lost about 14% of its primary forest resources (Vizzuality, 2021).

Next Wave Challenges of Climate Change

The impact of climate change in Nigeria is multifaceted. As opined by Amanchukwu *et al*. (2015), adverse heat will result in crops and vegetation damage, while heavy rainfall will enhance flooding and forced relocation of both humans and even animal species because such climates promote species richness (Dunn *et al.,* 2010; Schipper *et al.,* 2008) and therefore can support a multitude of potential hosts to sustain parasitic diseases**.**

The entirety of climate change negatively affects gross domestic product (Anabaraonye *et al*., 2019; Solomon and Edet, 2018; Ogbuabor and Egwuchukwu, 2017; Ebele and Emodi, 2016)).

Habitat Loss and Fragmentation

Habitat alteration due to climate change is a major threat to ecosystems, often leading to substantial loss of biodiversity, ecosystem functioning and services (Katovai *et al.,* 2012; Edwards *et al.,* 2014). This in turn will alter host-parasite interactions, by either increasing (McKenzie, 2007; Mbora *et al.,* 2009; Hussain *et al.,* 2013) or decreasing (Lane *et al.,* 2011; Chasar *et al.,* 2009 and Evans *et al.,* 2009) infection levels, depending on nuances of host and parasite life history.

Disease transmission

Climatic conditions strongly affect water-borne diseases and those transmitted via insects, snails

or other cold-blooded animals. Climatic changes are likely to lengthen the transmission seasons of important vector-borne diseases as well as altering their geographic range. For example, climate change widens significantly, snail-borne disease, schistosomiasis (WHO, 2018).

Agricultural Sector

About 70% of Nigeria's population depends on agriculture as their ultimate source of living (Federal Ministry of Environment, FMOE 2014; Onwutuebe, 2019). Variations in temperature, rainfall and other climatic factors will adversely affect some crops. Flooding and erosion of farmland will also lower agricultural production (Ogbuabor and Egwuchukwu, 2017), resulting in low food production and low fish yield because of the increase in water level. Nigeria's governments as well as different agencies have engaged in various efforts to combat climate change and its impacts, particularly in the agricultural sector which is crucial to the country's economy and wellbeing of its citizens (Ifeanyi-Obi and Nnadi, 2014). Results reached to date are poor, however, including ongoing agricultural losses despite access to weather information. This portrays the fact that the government and other agencies efforts are yet to be adequate (Ifeanyi-Obi and Nnadi, 2014).

Transportation

Nigeria's transportation system has under-maintained road networks, which is further tainted by harsh weather condition (BRNCC, 2011). The rise in sea level will result in costly changes to other ports, while increase in sea water may damage railway system (Ebele and Emodi, 2016). These climatic changes negatively influence Nigeria's economy.

Security

Presently, climate change poses threats to the security situation in Nigeria through conflict over resources. This is aggravated by the increase in water and food scarcity; growing land scarcity stemming from desertification; increasing climate-induced migration; and rising poverty (Madu, 2012, 2016; BNRCC, 2011). Northern states are more prone to serious food threats, throughout the country (Madu, 2012); while growing desertification forced thousands of Fulani herdsmen to move to other regions, resulting to clashes with farmers (Jumoke, 2016). If nothing is done to salvage the adverse climatic situation, more threats may arise from this angle.

Fig. 1: *Forced migration due to climate change (Adapted from Jumoke, 2016).*

Energy

Low rainfall in the Northern part of the country reduces the availability of trees and other vegetation used for fuel, which affects hydroelectric output as in the case of Kainji and Shiroro dams (FMOE, 2003; BNRCC, 2011; Ebele and Emodi, 2016). Drought also leads to higher evapotranspiration which grossly affects water volume, thus reducing hydroelectric capacity (BNRCC, 2011; Amadi and Udo, 2015; Ebele and Emodi, 2016). Hence, thermal energy will be affected by variation in climate, because it is dependent on the amount of, timing and geographical pattern of temperature and precipitation (Ebele and Emodi, 2016).

Conclusion

All populations will be affected by climate change, but some are more vulnerable than others. Children in particular, living in poor countries are among the most vulnerable to the resulting health risks and will be exposed even longer to the health consequences. The health effects are also expected to be more severe for elderly people and people with infirmities or pre-existing medical conditions. Areas with weak health infrastructure- mostly in developing countries will be the least to cope without assistance to prepare and respond.

Nigeria being a country with tropical climate has two precipitation regimes; low precipitation (Northern part) and high precipitation (Southern part). These have varying effects on the economy in general. Recently, Nigeria in partnership with United States (**Kingsley and Joke; 2022**), France (Vivian, 2023) has signed agreement on ways to mitigate the impacts of climate change. A lot still has to be done in terms of creating awareness to the populace on the dangers of climate change. Policy makers need to address this challenge at all levels of governance (Federal, State and Local Government Areas). The private sector also needs to assess, invest, plan and execute projects to mitigate its effects. Also, agricultural innovation that increases soil nutrients and do not contribute to climatic changes should be encouraged. Information and knowledge sharing must be made available to a wide range of people, especially the vulnerable group. The mass media should also be curbed into the game of disseminating this information. The study of climate change should also form part of the Nigerian educational curriculum. Provision of incentives to researchers should be prioritized, for a practical solution to the problem of climate change.

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Analysis Of Climate Variability Coping Strategies Used By Arable Farmers In Abak Agricultural Zone Of Akwa Ibom State, Nigeria

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Abstract : *The study examined climate variability coping Strategies used by Arable Crop Famers in Abak Agricultural Zone of Akwa Ibom State, Nigeria. Primary data were obtained a random selection of 160 arable crop farmers for this study. Questionnaire consisting of subsections which reflected the specific objectives of the study was used in data collections. Data collected for the study were analyzed using frequencies, percentages and means (M) and severity index. Most of the arable crop farmers used for the study claimed to have used varieties of coping strategies, weeding and pest control (M= 3.57), exposure of the farmland to sunlight radiation (M=3.43), early and timely planting of crops, The use of organic manure (M=3.26) and mulching (M=3.16) were the most climate variability coping strategies used. Furthermore, high cost of strategies had a severity index of 0.843 which means that majority (84.3%) of the respondents were faced with this constraint. Low income and shortage of labour had severity index of 0.82.2 respectively. This is an indication that 82.2% of the respondents were constrained with these factors. It was recommended that Farmers be encouraged to practice multiple adaptation strategies because this will aid in high crop yield and profit per hectare hence, will increase the income level of farmers since one of the constraints to adapting measure in combating the adverse and negative effect of climate variability was farmers' low income.*

Keywords: Climate. Adaptation, Variability and Arable Crop Farmers

CITATION:

Okorie, N. U., Umoh, I. and Okon, U. E. (2023). Analysis of Climate Variability Coping Strategies Used by Arable Farmers in Abak Agricultural Zone of Akwa Ibom State, Nigeria. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp 287-291

Introduction

Climate variability according to Ekpoh and Ekpoh (2011) is a term that is used in describing variations in the mean state and other characteristics of climate (such as chances or possibility of extreme weather, etc.). The warming of the world climate has been linked to higher concentration of carbon dioxide and other greenhouse gases (GHGs) in the atmosphere, which are dominantly of anthropogenic origin such as fossil fuel combination, land use and deforestation (Intergovernmental Panel on Climate Change - IPCC, 2007). Climate variability phenomenon has serious deleterious consequences for the earth in the form of significant variations in regional climates, recurrent droughts, excessive heat waves, windstorms, killer floods, and so on. There are noticeable consequences of climate change in Nigeria such as intense thunderstorms, widespread floods and incessant droughts. Odey (2009) pointed out that climate variability impacts pose great dangers with

consequences such as desertification, sea level rise, flooding, water salination, among others. These impacts could manifest in food security challenges, damage to infrastructure and social dislocation.

Small-scale farmers are among the first to feel the impacts of climate variability because of their greater dependence on the natural environment. Extreme climate variability (drought, floods and frost) can destroy the economies and welfare of poor rural families because they lack technologies, social protection mechanisms (such as benefits, insurance and savings) and adequate protection for their crops and animals. Hence, the capacity to adapt varies considerably between families even within the same community. Adaptation to climate change is a process that initially requires famers to perceive that the climate has changed and then identify the necessary adaptations to be implemented (Mustapha *et al*., 2014). Thus, the ability of a system (human or natural) to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences" (Juana *et al.*, 2013)

Changes in the frequency and severity of extreme climate events and in the variability of weather patterns will have significant consequences for human and natural systems. Increasing frequencies of heat stress, drought and flooding events are projected for the rest of this century, and these are expected to have many adverse effects over and above the impacts due to changes in mean variables alone (IPCC, 2012). Arable crop farmers embark on various cultural practices that lead to the production of various crops and in few cases livestock. Such cultural practices include: selection of land, use of appropriate seed bed, selection of planting materials, adoption of appropriate technologies in the conservation of or enhancement of soil fertility (use of fertilizers, manures, lime, crop rotation etc.), adherence to good agronomic practices land clearing, planting, farm hygiene, pest control, weeding, harvesting etc.

Levels of arable crop production are controlled to a large extent by natural environmental conditions, especially the climate and soil fertility status (edaphic factors). The interdependence between crop, human and edaphic factors make it mandatory for arable crop farmer to have in-depth knowledge of the factors that affect crop production (Udoh *et al.,* 2005). Agricultural activities are very sensitive to climate and weather conditions.

For Nigeria and Akwa Ibom in particular, there is the looming threat of food insecurity. Arable lands are dwindling, climate change is taking a toll on agricultural practices, the farming population is aging and going extinct, famine is ravaging the Horn of Africa.For instance, Nkeme (2016) observed that farmers rate of adoption to climate change mitigation technologies in Uyo agricultural zone was quite low.This has created a serious concern to all stakeholders and farmers in Akwa Ibom State, especially, arable crop farmers in Abak Agricultural Zone of Akwa Ibom State, Nigeria , who have the largest role to play in making agriculture both climate-smart and more productive by adapting to climate variability. This study was aimed at analyzing climate variability adaptation strategies used by arable crop farmers in Abak Agricultural Zone of Akwa Ibom State and examined constraints faced by the arable crop farmers in using climate variability adaptation strategies in the study area

Methodology

The study was carried in Abak Agricultural Zone of Akwa Ibom State, Nigeria. A Multi-stage sampling procedure was deployed in the selection of the respondents for the study. In the first stage, Five (5) blocks were randomly selected. Secondly, Four (4) cells were randomly selected from each of the selected blocks in the zone making a total of Twenty (20) cells. Finally, Eight (8) arable crop farmers were randomly selected from each of the Twenty (20) cells.

Therefore a total of 160 respondents were selected for the study. Frequency, percentage, mean and severity incidence were applied to analyse the data for the study.

Results and Discussion

Climate Variability coping Strategies used by the Respondents

Adaptation reduces the effect and boost resilience to climate variability. Coping strategies used by the respondents are shown in Table 1. Although most of the arable crop farmers used for the study claimed to have used varieties of coping strategies, weeding and pest control (M= 3.57), exposure of the farmland to sunlight radiation (M=3.43), early and timely planting of crops, The use of organic manure (M=3.26) and mulching (M=3.16) were the most climate variability coping strategies used. This agrees with the findings of Ifeanyi-obi *et al*., (2012) which examined that farmers adapt various coping strategies to reduce the effect of climate change in Nigeria and some of these coping strategies are early and timely planting, organic farming, resistant varieties and mulching.

Table 1: Climate Variability Coping Strategies used by the Respondents

S/N	Climate Variability Coping Strategies	AL	ST	RL	NV	Mean	MR
1	Early and timely planting of crops	51.3	34.9	5.9	7.9	3.29	3rd
2	Use of irrigation system/water storage	33.6	35.5	16.4	14.5	2.88	12th
3	Planting cover crops to help conserve soil moisture	30.3	28.9	21.7	19.1	2.70	17th
4	Multiple cropping (planting different types of crops)	49.3	25.0	13.2	12.5	3.11	6th
5	The use of organic manure	50.0	33.6	9.9	6.6	3.26	4th
6	Minimum/zero tillage to help conserve soil nutrient	33.6	33.6	17.8	15.1	2.85	14th
7	Planting pest and disease resistance crops	34.2	32.2	19.1	14.5	2.86	13th
8	Adopting recommended planting distance	40.8	29.6	13.2	16.4	2.94	10th
9	Changing crops harvesting dates	34.2	34.9	17.1	13.8	2.89	11th
10	Mulching	44.7	32.9	15.1	7.2	3.15	5th
11	Practice of crop rotation	40.8	33.6	15.1	10.5	3.04	8th
12	Use of drought resistant crops when the season is experiencing drought	38.8	23.7	21.7	15.8	2.85	14th
13	Making of water ways to channel runoff water when there is prolonged rain	41.4	29.6	17.8	11.2	3.01	9th
14	Exposure of the farmland to sunlight radiation	67.1	15.8	10.5	6.6	3.43	2nd
15	Weeding and pest control	72.4	16.4	7.9	3.3	3.57	1st
16	Planting short season crops	20.4	37.5	23.7	18.4	2.59	18th
17	Shifting cropping dates	29.6	34.2	19.1	17.1	2.76	16th
18	Planting of fast maturing crop varieties	40.1	32.9	20.4	6.6	3.06	7th

Source: Field Survey, 2021. Note: Values represents the percentages.

Key: AL = Always, ST = Sometimes, RL = Rarely, NV = Never, MR = Mean Ranking

Analysis on Constraints Faced by the Respondents in using climate variability coping Strategies the Study Area

Table 2 presents the constraints faced by the arable crop farmers in the use of adaptation strategies in the study area. It was revealed that high cost of strategies had a severity index of 0.843 which means that majority (84.3%) of the respondents were faced with this constraint. Low income and shortage of labour had severity index of 0.82.2 respectively. This is an indication that 82.2% of the respondents were constrained

with these factors. The problem of low income may hinder farmers to acquire necessary facilities and training. Other constraints were; Inadequate supporting infrastructure (0.815), Land related issue (0.802), lack of relevant information (0.783), and inadequate contact with extension agents (0.75). These corroborate the findings of World Bank (2011); Flor, Gummert, Maligalig, Pyseth, and Vichet, (2010) poor extension services limits farmers in using climate change coping strategies.

Table 2: Constraints Faced by the Respondents in using climate variability coping Strategies the Study Area

S/N	Constraints	Very Serious	Serious	Not Serious	Severity incidence
1	Lack of awareness	38.2	26.3	35.5	0.645
2	Low income	53.3	28.9	17.8	0.822
3	High cost of strategies	46.1	38.2	15.8	0.843
4	Lack of technical knowhow	48.7	22.4	28.9	0.711
5	Inadequate contact with extension agents	50.7	24.3	25.0	0.755
6	Cultural beliefs	23.0	19.7	57.2	0.427
7	Fear	22.4	33.6	44.1	0.560
8	Shortage of labour	41.4	40.8	17.8	0.822
9	Lack of relevant information	44.7	33.6	21.7	0.783
10	Inadequate supporting infrastructure	52.6	28.9	18.4	0.815
11	Land related issue	51.9	36.3	90.8	0.802

Source: Field Survey, 2021.

Conclusion and Recommendations

Most arable crop famers have adapted measures or strategies in combating the adverse and negative effect of climate variability but are faced with severity of constraints to these measures. These include; high cost in using these measures, low income, shortage of labour, lack of relevant information and land related issue. Based on the findings of this study, the following recommendations are made; support be given to extension workers to adequately disseminate and educate farmers on issues of climate variability since lack of relevant information was a major constrained. Farmers be encouraged to practice multiple adaptation strategies because this will aid in high crop yield and profit per hectare hence, will increase the income level of farmers since one of the constraints to adapting measure in combating the adverse and negative effect of climate variability was farmers' low income.

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Emerging Issues In Higher Education Administration In Nigeria And The Way Forward

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Abstract: *The paper considered a brief historical perspective of higher education in Nigeria, an overview of higher education administration and its emerging issues and the way forward. The emerging issues were identified to include; core curriculum minimum, academic standards (CCMAS) and matters arising, selection of Vice Chancellor, inadequate funding, inadequate lecturers, politicization of educational issues, inadequate infrastructural facilities, institutional corruption, industrial actions by ASUU, brain drain and low research output. Using the secondary sources, the issues identified were discussed and the recommendations made to address the issues made as follows; recruitment of professionals in educational administration and planning as heads of educational institutions, adequate funding of higher education, employment of more qualified lecturers, provision of adequate infrastructural facilities, depoliticisation of Vice Chancellorship selection, checkmating corruptive practices in the university system, improved incentives for lecturers, implementation of agreements with Unions by government, prioritizing research grants and institutionalizing good governance in the Nigerian universities system.*

Keywords: Education Administration, Emerging Issues, Higher Education, Higher Education Administration

CITATION:

Umosen, A. O. and Ereh, C. E. (2023). Emerging Issues in Higher Education Administration in Nigeria and the Way Forward. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp 277-286

Introduction

Education in all dimensions is one sector that is currently contributing to the social, economic, political, scientific and technological development in Nigeria, in spite of a plethora of issues surrounding its implementation at higher education level. Sule *et al*., (2012) assert that education is not only regarded as a very important instrument of socialization and reform, but as a means of laying the foundation for a strong and united nation. Education in Nigeria is built on three tiers, namely; basic education, post-basic education and higher education, each with its clearly adumbrated objectives aimed at achieving the country's philosophy of education through institutionalized core curriculum minimum academic standards (CCMAS) as recently articulated by National Universities Commission (NUC). The thrust of this paper is focused on a brief historical perspective of higher education in Nigeria, overview of higher educationadministration and consideration of

emerging issues in higher education administration in Nigeria and the way forward.

Historical Perspectives of Higher Education in Nigeria

Nigeria's higher education system consists of a university sector and a non-university sector comprising; polytechnics, monotechnics and colleges of education (Federal Republic of Nigeria (FRN) 2013). The emergence of higher education in Nigeria dates back to 1948 when the first University College was established in Ibadan as an affiliate of the University of London (Ibia, 2011). After her independence, university in Nigeria experienced a spurt growth as citizens' yearning for higher education increased. By 1962, five federal universities were established, namely; University of Ibadan, University of Ife, University of Nigeria, Ahmadu Bello University and the University of Lagos (www.nuc.edu.ng/nigerian universities/federal universities). Subsequently, higher education in Nigeria recorded geometrical growth with the ambition to secure sustainable growth and invest in Nigerian people with a focus on economic diversification, investment in infrastructure, reducing poverty, inequality and unemployment, and fostering a strong society and human capital (www.acioe.com).

Currently, there are 48 federal, 58 state and 99 private universities as accredited degree-granting institutions. Of all these institutions, National Universities Commission (NUC) affirmed that the largest part of students are enrolled with federal universities (68 percent) and state universities (27 percent) while private universities account only for 5 percent of total higher education student population. (www.nuc.edu.ng/nigerian-universities/ federal universities). The above statistics on student population in federal universities are the consequences of rapid infrastructural decay in the system, followed by staff personnel demands, high administrative costs and high demand for revitalization fund by universities lecturers. It has been aptly observed that while the demand for higher education is growing geometrically, university funding is retrogressive. This approach to Nigerian higher education funding seems to frustrate the effort of the universities administrators as well as the set objectives of higher education.

It is apparent, that government is lethargic to appropriate adequate fund for higher education and other tiers of education based on 26% UNESCO recommendation. Secondly, the existing universities infrastructures suffer overused and wornout due to years of longexistence without overhauling, adequate maintenance andor replacement to accommodate the high demand for higher education in Nigeria.In addition, the government appears to have jettisoned the strategic and pragmatic approaches to educational planning considered inalienable to the development of higher education system, its programmes and the workforce in line with global practices. From the foregoing, the higher education institutions in Nigeria can hardly work maximally to sustain its mandates and produce quality graduates who are employable or employers of labour. This is because most captains of industries in Nigeria see the present-day graduates as lacking the innovative and entrepreneurial skills required by the present technological era to make meaningful contributions to the development of the industrial sector and the nation's economy at large.

Higher Education Administration in Nigeria: An Overview

Higher education administration refers to the comprehensive management of higher institutions such as polytechnics, monotechnics, colleges and universities, having the responsibility of overseeing curriculum, programmes, staff members, students and educational progress (www.igi-

global.com>higher). It also means ensuring adequate planning and effective coordination of available human and financial resources including infrastructural facilities in the university system with a view to providing quality teaching and learning for a successful educational outcome. Higher educational administrator or the Vice Chancellor is the pivot on which all educational activities revolve in the university system. Hence, the success or failure of the programmes for an individual institution depends to a great extent on the quality of the administrator's leadership, resourcefulness, creativity, result oriented capacity, stimulating quality performance technique and appraising how institutional goals are being achieved (Unachukwu and Okorji, 2014).

The focus on higher education administration in Nigeria shows high level of leadership and administrative expertise exhibited by some educational administrators/vice chancellor amidst scarcely available human, material and financial resources to pursue the cardinal objectives of the university system. In the contrary, many other administrators are engrossed in mismanagement and misappropriation of the financial resources in the system, thereby contributingto the deteriorating quality of Nigerian higher education (Nwachukwu, 2016). It was further observed that financial misappropriation of TETFund meant for researches resulted in the reduction of allocation to some universities. These practices contribute to the large outcry from the lecturers on the issue of grossly of adequate research funding for research purposes (www.guardianngr.>).

The university governance requires some paradigm shift in administrative approach to overcome some negative practices that are not in tandem with its aspirations. Thus, there is need to institutionalize transformational leadership type. This leadership is characterized by exemplary character in service delivery with a view to achieving institutional set goals, absence of which the organization is plagued with many issues (Umosen, *et al*., 2022).Thus, the emerging issues in higher education administration in Nigeria considered, include the following; Core Curriculum Minimum, Academic Standards (CCMAS) and matters arising, selection of Vice Chancellor, inadequate funding, inadequate lecturers, politicization of educational issues, inadequate infrastructural facilities, institutional corruption, industrial actions by ASUU, brain drain and poor research.

EMERGING ISSUES IN HIGHER EDUCATION ADMINISTRATION

Core Curriculum Minimum Academic Standards (CCMAS): Matters Arising

In keeping with its mandate of making university education in Nigeria more responsive to the needs of the society, NUC recently restructured the former policy framework, Benchmark Minimum Academic Standards (BMAS) articulated in 2018 by introducing in its place, Core Curriculum Minimum Academic Standards (CCMAS). The intention is to reflect the 21st century realities in the existing and new disciplines and programmes in the Nigerian University System.The cardinal objectives of CCMAS is to ensure employability of university graduates who are unemployable due to lack of acquisition of exceptional employable skills.

However, laudable the new policy initiation is, its gestation is in doubt given the unfavourable school climate in operation, which is stifle of adequate funding andsuffer decayed infrastructural facilities to support the new curricula development as well as the entrepreneurial programmes. Currently, most universities in Nigeria suffer shortages of staff members in skills acquisition in the specified areas where students are expected to acquire some skills and become employable and or employers of labour. Statistics also reveal that 20 out of 205 federal, state and private

universities in Nigeria offer entrepreneurship as a course of study (www.samphina.com.ng>universities), whereas the policy execution should cut across all higher education institutions in Nigeria. It is against this background, that fears are alleged that the new policy may not be very successful as envisaged.

Selection of Vice Chancellor

The Vice Chancellor is the institutions' Chief Executive. The VC is also the Chairman of Senate as well as Chairman of other Joint Committee of Council and Senate. By statutory laws, VC is chargedwith the responsibility of ensuring efficient administration of the University. It has been observed that at the expiration of a particular tenure, the emergence of a new VC is marked by many irregularities and flaws (Olukoju, 2021). The reasons for some VCship selection crises include; intrusion of vested interest by the Governor, political bigwigs, Council Chairman and influential members of Governing Council, senatorial zone balancing, nepotism, ethnicity, and religious issue, who prefers a family member, friend, loyalist or surrogate to assume the office. Apparently, the VC should be selected based on academic and administrative abilities as well as character while the rubric of contribution to knowledge in various fields should be aptly considered.

It is surprising to note that cases of VC crises abound and do frustrate the immediate assumption of office as consequence of such imbroglios. Suleiman and Akinlotan (2022) observed inside controversy trailing Vice Chancellor's appointment in Obafemi Awolowo University (OAU) as VC designate was disregarded in favour of an indigeneship criterion. In University of Ibadan (UI) the VC's appointment was laden with numerous petitions against the selection process. Thus, the crisis lasted for a period of two weeks after appointment (Alabi, 2020). Implications that followed delay of appointment of VC; include truncation of university programmes and policy implementation among other things. These crises ridden situations of allowed to continue unabated would further negate the primal objectives of establishing higher education institutions in Nigeria.

Inadequate Funding

One of the most critical issues facing higher education administration in Nigerian universities is inadequate funding. Inadequate funding simply means poor provision of funds for the universities current and re-current expenses which tends to inhibit effective higher education administration. Ogunode and Abubakar (2021) observed that the annual budgetary allocation for the administration of universities in Nigeria is grossly inadequate as it pendulumed between 6-7% for the past one decade against UNESCO recommendation, which is 26% of national budget for education. Ige (2013) observes that without adequate funding, standards of education at any level shall tantamount to a mirage. This is because money is needed to construct buildings, purchase needed equipment, pay staff-members salaries, etc. It has also been noted, that underfunding of the university system in Nigeria is responsible for poor researching, ineffective teaching, paucity of infrastructural facilities and human resources inadequacies (Okoli *et al.,* 2016; Ogunode *et al.,* 2019). These opinions suggest that no educational institution can carry out its functions efficiently without adequate funding. For instance, the 2023 budget totaling N21.83 trillion has a paltry appropriation of N1.08 trillion (7.9%) for the education sector (Suleiman, 2022). This is far from UNESCO recommendation; thus, it negates the effort of higher education institutions towards the realization its goals and aspirations.

Inadequate Lecturers

Lecturers are the workforce in the University system vested with the responsibility of teaching, researching and conducting community services. Therefore, their adequacy in quantity and quality contributes to the successful realization of the goals and aspirations of higher education in Nigeria. Unfortunately, most universities in Nigeria are currently understaffed. Ogunode and Abubakar (2020) assert that many higher institutions in Nigeria do not have adequate academic staff to implement their prescribed objectives and presently, the available ones are overstressed with excess workloads.

According to NUC, 100,000 academic staff members attend to 2.1 million students in Nigeria Universities (Sahara Reporters, 2022); while non-academic personnel are 170,000 in Nigerian universities. Comparatively, in the foreign universities, the difference is appalling. For instance, staff-to-student ratio in Harvard University is 1:4, Massachusetts Institute of Technology has 1:9 ratio, while University of Cambridge has 1:3. The above statistics reveal wide disparities between Nigerian universities and their counterparts in other parts of the world (Jacob and Musa, 2022). National Economic Empowerment and Development Strategy (NEEDS, 2014) maintained that deficiencies in staffing have led to a situation in which many universities have to rely exclusively on part-time and underqualifiedacademic with negative implications for quality education in the institutions.

Politicisation of Educational Issues

Politicisation is a noun derived from the verb 'politicise' which means to give a political character or tone to an issue (Jejunum, 2003). It further means thrusting politics into issue that was never before known to be a political issue. Politicization of education is considered from the perspective of manipulating education for political gains. Okeke (2007) asserts that politics of education focuses on education as an area of public policy and public responsibility, and the exercise of power on education priorities. The above definitions reveal that involvement of unqualified personnel either as teachers or administrators in educational institutions is a political matter to satisfy an individual interest because of his political office or connection with some persons who wield some political influences.

In Nigeria, politics of education is inextricably twisted with the interest of state, political parties especially ruling party and the nation in the area of tertiary institutions establishment, funding of education, accreditation of programmes, staff personnel appointments and even promotions (Umosen, 2020). Onoja (2017) observes a steady decline in education consequent upon politicization of education in Nigeria, in terms of political appointments. Osuji (2011) posits that politicking administration of education through undue government interference has resulted in some negative impacts such as bias in appointment of heads of institution. Ijor and Alye (2015) observe that allocation that goes into education is politically influenced. Ukpong (2017) also observes that politicizing administration of education has negative impact on human resources in education industry. For instance, government ban on employment has spelt negative effect on schooling, in terms of inadequate lecturers in the university system.

Inadequate Infrastructural Facilities

The dearth of infrastructure and facilities for enhanced teaching and learning in Federal Universities in Nigeria is notably worrisome as attested to by both students and lecturers. There are acute shortages of lecture halls, no equipments for practical, no sufficient desks/seats for lectures, no electricity supply to illuminate classrooms and provide power supply to workshops and laboratories, etc.

Ehichoya and Ogunode (2020) aptly acknowledged that the higher education institutions in Nigeria are characterized with diverse challenges including inadequate infrastructural facilities. Lawanson and Gede (2011) affirmed that school facilities are the educational resources that enable the lecturers to discharge their teaching responsibilities and to help the learners to learn effectively, without which it is impossible to achieve the purpose of learning in the school system.

Institutional Corruption

Institutional corruption refers to all forms of illegal practices including maladministration and misappropriation of fund within the university system. Jacob and Lawan (2020) identified cases of institutional corruption to include but not limited to; bribery to get promoted ahead of one's contemporaries in the same university, faculty or department; NYSC mobilization before graduation, facilitating fake transcripts, short-circuiting employment procedures, auctioning university assets without authorization, politicizing both staff members/students disciplinary action, inflating contracts, admission irregularities and racketeering, sexual harassment, abetting examination malpractices, unmerited allocation of hostel accomodation. Ogunode *et al*., (2018) further observed that corruption in Nigerian universities include, money laundering and ghost worker syndrome. In sum, no meaningful educational administration can take place in a corrupt educational system.

Industrial Actions by ASUU

Industrial action is the boycott of workforce after exhausting other means of dialogue between the employees and the employer(s) from gainful involvement in teaching process in the university system. Ogunedo *et al*., (2021) see incessant strike action by ASUU in the universities as another dimension of institutional problem which hinders effective educational administration in Nigeria. Any strike action by ASUU has the tendency to frustrate the successful completion of an academic programme within its expected terminal date. For instance, 2022 ASUU industrial action lasted for 8 months (February 14 – October 14, 2022) thereby truncating academic programmes for a full session (Erunke, 2022). Matters arising from the prolonged industrial action as experienced by ASUU members is the strangulating economic hardship the Nigerian universities lecturers are exposed to as consequence of the Industrial Court judgment and invocation of "no work, no pay rules".

Brain Drain

Brain drain refers to the mass exodus of lecturers from the Nigerian universities to greener pastures otherwise known as developed countries which promises improved work environments and corresponding incentives. The determinants of brain drain in the Nigerian universities include among other variables; poor working conditions, excess teaching workloads, poor salaries, poor access to research grants, irregular promotion and incessant industrial actions in the university system. Chukwuemeka (2020) attributes causes of human capital flight in Nigeria to; low paying jobs, lack of financial security, bad leadership, unfavourable working conditions, corruption, incessant crises, etc.

Consequently, brain drain has been identified as one of the factors stalling the growth and development of a nation. The effects of brain drain include, reduction in quality service, decrease in the standard of education, retardation in economic growth, reduction in technological development and the likes. Brain drain is assessed as a clog in the wheel of Nigeria development (Emeghara, 2013). The continuation of this migration process from the Nigerian universities will remain unabated as the situation in the system gets worst by the passing of each day.

Low Research Output

After teaching, research becomes the second major function of higher education institutions as prescribed in the national policy on education of Nigeria. Research focuses majorly on problems solving especially emerging issues in the society. It is apt to say, that world-class research requires availability of adequate funding, uninterrupted electricity supply, internet connectivity and functional computer facilities. However, research in higher education institutions in Nigeria is seemingly low due to low research funding. Often times, lecturers embark on research for promotion purposes because of its capital demands. Thus, low reports on lecturers' research capacity. Studies revealed that the standard of research in Nigeria universities is low compared with universities in developed countries (Desmennu and Owoaje, 2017). Baro *et al*., (2017) observed that research activities in Nigerian institutions have not received the proper attention due to insufficient funding. A country like South African has robust research grant opportunities compare to Nigeria for lecturers and students in various universities (Mba, 2019). Mouton (2016) observed that South African universities annually receive funding amounts calculated based on students, staff members and infrastructure. This is because the grants come from government and different other agencies. Whereas the Nigerian government commitment to research development is primarily from the TETFund which is grossly inadequate for 205 federal, state and private universities in Nigeria (Oraka *et al*., 2017) Aina *et al.,* (2021) posited that the little available funds in universities for research are mismanaged due to corruption and the impact hampers sustainable development in Nigeria.

Way Forward

Higher education in Nigeria is remarkable because of its identified objectives, but the attainment of these objectives depends on efficient administrative expertise exhibited by each educational administrator in Nigerianuniversities. Inspite of the emerging higher educational administration issues identified and discussed above which serves as a clog in the wheel of progress, the following suggestions are made to nip the problems in the bud; recruitment of professionals in educational administration and planning as heads of educational institutions, adequate funding of higher education, employment of more qualified lecturers, provision of adequate infrastructural facilities, depoliticisation of Vice Chancellorship selection, checkmating corruptive practices in the university system, improved incentives for lecturers, implementation of agreements with Unions by government, prioritizing research grants and institutionalizing good governance in the Nigerian universities system.

1. Professionals in educational administration and planning with indepth knowledge and experience should be appointed as heads of Nigerian universities to provide the needed policy initiation, execution, evaluation and feedback processes.

2. Adequate funding of Higher Education: Educational industry in the world is capital intensive in all ramifications. The government in conjunction with the private sector should work towards achieving and sustaining UNESCO 26% benchmark on the national budget to the educational sector.

3. Employment of more Qualified Lecturers: State of emergency should be declared in the educational sector with particular attention to employment of more qualified lecturers in the Nigerian universities, to cater for the manpower need arising from retirement of staff, death, and unbundling of Faculties and Departments.

4. Provision of Adequate Infrastructural Facilities: Adequate infrastructural facilities should be provided in all the universities in Nigeria to meet the high demand for higher

education. They include; lecture halls, staff offices, libraries, laboratories, toilet facilities, hostel accommodation, electricity, internet services, water supply, workshop and basic equipment, etc. to enhance effective teaching and learning.

5. Depoliticisation of Vice Chancellorship Selection: Selection of Vice chancellor in Nigerian universities should follow due process and based, largely on academic and administrative abilities while good character and high sense of public relations should be an added advantage to the candidates.
6. Checkmating Corrupt Practices: The federal government and heads of university governance should deploy the use of ICT devices to stall/curb illegal practices in the university system. Also, as much as possible, legal mechanisms and relevant anti-corruption agencies should be involved in cases of corruption to fish out culprits from the system.
7. Improved Incentives for Lecturers: Lecturers should be duly motivated on their job involvement for quality outputs using incentives such as professional development programmes, rewards programme, service awards,social recognition as well as monetary incentives.
8. Implementation of Agreements with ASUU by Government: Government should show high level of public trust by ensuring that all agreements reached with ASUU and other higher education institution Unions are implemented. This sincerity of purpose on the part of government would further boost congenial work environment and quality educational outputs.
9. Prioritizing Research Grants: The educational sector is capital demanding in teaching, researches and rendition of community services. There should be collaboration in research funding in higher education institutions by both government and private sector. Also, collaboration should be encouraged between the universities and industries to know the social needs that require modern research to grow the national economy.
10. Institutionalizing Good Governance: Brain drain has been identified as offshoot of bad governance. When bad government is enthroned, the indices include; corruption, oppression, internal wrangling, insecurity and the likes. In the contrary, institutionalizing good governance promotes; rule of law, transformational leadership, probity and accountability, economic recovery, poverty reduction and even development. It is apparent that economic boom and political stability would abound while brain drain would be annihilated.

Conclusion

It is obvious that emerging issues in higher education administration in Nigerian universities are not unconnected with ineffective administration in the system coupled with poor funding from government. The increasing demand for admission by candidates for higher education amidst infrastructural facilities decay poses further problem to educational administration in Nigeria. The paper critically identified the issues and proffer solution in order to contribute meaningfully to the development of higher education administration in Nigeria and the nation at large.

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The Role Of Artificial Intelligence In Educational Development

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Abstract: *The study of intelligent machines that can carry out tasks that traditionally require human intelligence, such as speech recognition, decision-making and language translation, is known as artificial intelligence (AI). AI comes in many different forms, such as rule-based systems, machine learning (ML) and deep. AI works by combining large amounts of data with fast, iterative processing and intelligent algorithms, allowing the software to learn automatically from patterns or features in the data. Artificial intelligence (AI) involves using computers to do things that traditionally require human intelligence. AI can process large amounts of data in ways that humans cannot. The goal for AI is to be able to do things like recognize patterns, make decisions, and judge like humans. AI drives down the time taken to perform a task. It enables multi-tasking and eases the workload for existing resources including education. AI enables the execution of hitherto complex tasks without significant cost outlays. AI operates 24x7 without interruption or breaks and has no downtime. All these benefits translating into educational development means a lot in this 21centry education needs especially in the developing world including Nigeria. It is high time Nigerian universities and other stakeholders in our educational system should think of ways of investing in Artificial Intelligent to meet the current trends in educational development by ensuring data gathering, infrastructure, manpower development, review of courses in computer science/education in Postgraduate programmes and many more like other advanced world.*

Keywords: role, artificial intelligence, educational development

CITATION:
Essien, N. P., Akpanobong, U. E. and Akpan, S. (2023). The Role of Artificial Intelligent (AI) in Educational Development. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp 270-276

Introduction

The term 'Artificial Intelligence' was first coined by John McCarthy in the Dartmouth Artificial Intelligence Project Proposal in 1956, when he invited a group of researchers to attend a summer workshop called the Dartmouth Summer Research Project on Artificial Intelligence to discuss the details of what would become the field of AI. The researchers consisted of experts from various disciplines, such as language simulation, neuron nets and complexity theory. The term 'AI' was picked for its neutrality, that is, to avoid a name that focused too much on either of the tracks being pursued at that time. The proposal for the conference stated: 'The study is to proceed on the basis of the conjecture that every aspect of learning or any other feature of intelligence can in principle be so precisely

described that a machine can be made to simulate it. An attempt will be made to find how to make machines use language, form abstractions and concepts, solve kinds of problems now reserved for humans, and improve themselves' (Brown, 2015). However, AI has only become more popular recently due to increasing volumes of data, development of more advanced algorithms, and refinement of computing power and storage. In addition, as the necessity for automating the more specific tasks in fields such as education and manufacturing increases, AI is gaining more attention in today's world. In the past, the development of AI has evolved in stages. From the 1950s to the 1970s, the growth of AI revolved around neural networks. From the 1980s to the 2010s, machine learning became popular and, today, the boom of AI is driven by deep learning (Smith, 2016).

Machine learning is a technique of data analytics that teaches computers to learn from experience, that is, from recurring patterns. MLAs utilize computational methods to learn directly from data without initially requiring a model in the form of a predetermined equation. As the sample size increases, the algorithm adapts and the performance of the algorithm improves. Machine learning uses two types of techniques, that is, supervised learning and unsupervised learning. Supervised learning methods such as classification and regression develop a predictive model based on both input and output data, so it gains the ability to predict output data based on input data, whereas unsupervised learning methods such as clustering group interpret data based only on input data so that they can find hidden complex patterns that exist in data (MaCarthy, 2021). Common algorithms for classification are support vector machines (SVMs) and k-nearest neighbour. Common algorithms for regression techniques are linear regression and nonlinear regression. Marr (2018) common algorithms for clustering are hierarchical clustering and subtractive clustering.

Liu (2015), AI is gaining importance for a number of reasons. Through the use of years of collected data, AI automates repetitive learning and the process of discovery. However, AI is more than just hardware-driven robotic automation that simply automates manual tasks. AI has the power to perform high-volume and frequent tasks reliably and without fatigue. More importantly, AI can even automate tasks that require cognitive abilities that were only possible previously by humans. Moreover, AI incorporates intelligence into existing products. In most cases, AI will not be packaged as an individual product. Instead, products that already exist in the market will be embedded with AI capabilities.

In the education sector, cognitive computing can become a heavy driving force in the teaching and learning process to maximize a student's potential. Similar to a teacher that has to go through numerous training and years of experience before they become skilful in educating students, a cognitive computing program needs to be fed with large amounts of data regarding the process of development of students and the syllabus in an education system before it can effectively aid in the process of education. The teacher cannot simply instantly transfer all their knowledge and education to a new student as inexperienced teacher does. A new teacher would need to go through years of training before they become as skilful as a seasoned teacher. However, a well-trained cognitive programme can quickly and easily be replicated without needing to perform the entire training process again. This makes it possible for cognitive computing to be used in classrooms as personalized assistants for each individual student, focusing on the strengths and weaknesses of each student and providing

the necessary level of difficulties in exercises so that the student improves quickly (Sears, 2018). This can relieve the stress that teachers face when teaching a class with a large number of students. A single teacher also cannot cater to the needs of each individual student without neglecting the progress of other students. Such a cognitive computing application in education can also develop many techniques, such as creating lesson plans for students. Today, AI in the education process already exists as mobile applications, such as Mika and Thinskter Math, virtual tutors that adapt to the needs of students and help them to improve in subjects.

Machine Learning (ML) and Artificial Intelligence

AI are essential drivers of innovation and growth in all sectors, including education. While AI-powered technologies have been around for a while in EdTech, the sector has been sluggish in their acceptance. The pandemic, on the other hand, radically altered the scene, pushing educators to rely on technology for virtual instruction. Now, 86 percent of educators believe that technology should be an integral element of education. AI has the potential to improve both learning and teaching, assisting the education industry, simultaneously evolving to benefit both students and teachers. Here is how AI can benefit both the students and the educators (Hajuk, 2016):

AI Benefits for Students

Artificial intelligence can help students learn better and faster when it is used with good learning materials and teachers. AI systems can also assist students in getting back on track faster by alerting teachers to issues that the naked eye cannot detect. To be precise, a student's sole purpose of going to an educational institute is to get a degree or credential demonstrating their expertise. AI can have a huge impact on students' educational journeys by offering access to the relevant courses, enhancing contact with teachers, and allocating more time to work on other aspects of life. Here are a few examples:

Personalization

Personalization is one of the most prominent educational trends. Students now have a customized way of learning programs that focus on their own distinct experiences and interests; thanks to AI applications. AI can adjust to each student's level of expertise, learning speed, and desired goals to ensure they get the most from their learning. Furthermore, AI-powered systems can examine students' previous educational histories, detect shortcomings, and recommend courses better suited for improvement, allowing for a highly personalized learning opportunity.

Tutoring

While it is not unusual for kids to require additional assistance outside of the class, many educators would not have the time to assist children after school. While no chat-bot can really replace a teacher, AI programs can assist students in honing their skills outside the classroom by helping with improving on weak areas. They offer one-on-one experiential learning without the teacher being available to answer questions at all hours of the day. In addition, an AI-powered bot can respond to queries in 2.7 seconds.

Quick Responses

Nothing is more aggravating than posing a question and having it answered 2 days later. On a regular basis, teachers and instructors are assaulted with repetitious queries. With the support of automation and cognitive intelligence, AI can assist students to get solutions to their most frequently asked questions in seconds. This not only saves teachers a lot of time but also students' time looking for answers or awaiting a response to their inquiries.

Universal 24/7 Access

AI-powered solutions make learning available to all students, at any time and from any location. Each learner has his own pace, and having 24/7 access allows kids to experiment with what works best for them without having to wait for an educator. Furthermore, students from all around the world can obtain high-quality learning without paying travel or living fees.

AI Benefits for Educators

Most teachers and staff are not ashamed to say they battle with time management, which makes sense given the number of tasks on their daily to-do lists. By automating chores, assessing student performance, and eliminating the educational gap, AI can assist in freeing up teachers' time. Here's how it works:

Personalization

Like AI can customize learning education courses for students, it can also assist teachers in their work. AI can provide teachers with a clear image of subjects and courses which need revaluation, by studying students' learning capacities and histories. This study enables teachers to design the most effective learning plan for every single student. By studying each student's particular needs, teachers and lecturers can tailor their courses to meet the most prevalent knowledge gaps or issue areas before a learner falls far behind.

Answering Questions

AI-powered chat-bots with accessibility to a school's entire base of knowledge can answer a range of generic and repetitive inquiries students commonly have without having to contact a faculty member. This way, AI frees up time for teachers to concentrate on curriculum design, coursework research, and ways of increasing student engagement.

Task Automation

AI's potential to automate the most basic job includes tasks such as replacing administrative labour, grading papers, measuring learning patterns, responding to general questions, etc. A Telegraph poll found that teachers spend 31% of their time organizing courses, grading tests, and doing administrative duties. Teachers, on the other hand, can use support automation systems to automate manual tasks, giving themselves more time to concentrate on improving their teaching competency.

Challenges in Artificial Intelligence in 2023

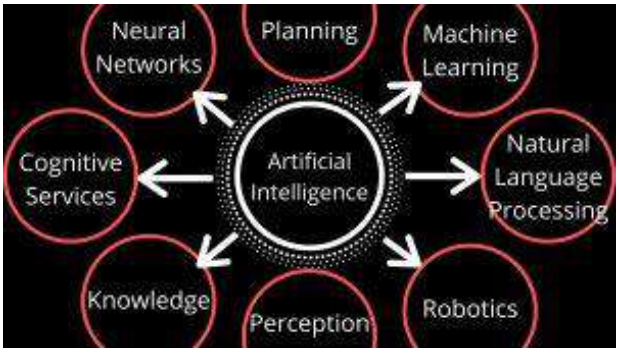

Fig. 1: Areas of AI Application

Source: The Nine Pillars of Technologies for Industry 4.0

In Nigeria, the training of technical personnel has witnessed formidable challenges ranging from poor funding to inadequate facilities both quantitatively and qualitatively, non-availability of adequate human capacity, brain drain and poor staff training and retention profiles. The impact of Artificial Intelligence on human lives and the economy has been astonishing. Artificial Intelligence can add about $15.7 trillion to the world economy by 2030. To take that into perspective, that is about the combined economic output of China and India as of today (Belt, 2021). With various companies predicting that the use of AI can boost business productivity by up to 40%, the dramatic increase in the number of AI start-ups has magnified 14 times since 2000. The application of AI can range from tracking asteroids and other cosmic bodies in space to predict diseases on earth, explore new and

innovative ways to curb terrorism to make industrial designs.

Top Common Challenges in AI

There are several Artificial Intelligence problems facing the developing countries which Nigeria is among:

a.) Computing Power:

The amount of power these power-hungry algorithms use is a factor keeping most developers away. Machine Learning and Deep Learning are the stepping stones of this Artificial Intelligence, and they demand an ever-increasing number of cores and GPUs to work efficiently. There are various domains that there are ideas and knowledge to implement deep learning frameworks such as asteroid tracking, healthcare deployment, tracing of cosmic bodies, and much more. These require a supercomputer's computing power, and it is not cheap. Although, due to the availability of Cloud Computing and parallel processing systems developers work on AI systems more effectively, it come at a price. Not everyone can afford that with an increase in the inflow of unprecedented amounts of data and rapidly increasing complex algorithms.

b). **Trust Deficit**

One of the most important factors that are a cause of worry for the AI is the unknown nature of how deep learning models predict the output. How a specific set of inputs can devise a solution for different kinds of problems is difficult to understand for a layman. Many people in the world do not even know the use or existence of Artificial Intelligence, and how it is integrated into everyday items for interaction with such as smartphones, Smart TVs, Banking, and even cars (at some level of automation).

c). Limited Knowledge

Although there are many places in education where Artificial Intelligence can be used as a better alternative to the traditional systems, the real problem is the knowledge of Artificial Intelligence. Apart from technology enthusiasts, college students, and researchers, there are only a limited number of people who are aware of the potential of AI especially in educational system in Nigeria. Aside from education, for example, there are many **SMEs (Small and Medium Enterprises)** which can have their work scheduled or learn innovative ways to increase their production, manage resources, sell and manage products online, learn and understand consumer behavior and react to the market effectively and efficiently. They are also not aware of service providers such as Google Cloud, Amazon Web Services, and others in the tech industry.

d.) Human-level

This is one of the most important challenges in AI, one that has kept researchers on edge for AI services in companies and start-ups. These companies might be boasting of above 90% accuracy, but humans can do better in all of these scenarios. For example, let our model predict whether the image is of a dog or a cat. The human can predict the correct output nearly every time, mopping up a stunning accuracy of above 99%. For a deep learning model to perform a similar performance would require unprecedented fine-tuning, hyper-parameter optimization, large dataset, and a well-defined and accurate algorithm, along with robust computing power, uninterrupted training on train data and testing on test data. That sounds a lot of work, and it is actually a hundred times more difficult than it sounds. One way you can avoid doing all the hard work is just by using a service provider, for it is possible to train specific deep learning models using pre-trained models. They are trained on millions of images and are fine-tuned for maximum accuracy, but the real problem is that it will continue to show errors and would really struggle to reach human-level performance.

e. Data Privacy and Security

The main factor on which all the deep and machine learning models are based on is the availability of data and resources to train them. There are data, but as this data is generated from millions of educational institutions around the globe, there are chances this data can be used for bad purposes. For example, let suppose an educational service provider offers services to 1 million institutions in a continent of Africa, and due to a cyber-attack, the personal data of all the one million institutions fall in the hands of everyone on the dark web. This data includes data about graduation, academic performance and much more. To make matters worse, it involve the whole country or continent. With this much information pouring in from all directions, there would surely be some cases of data leakage.

f.) The Bias Problem

The good or bad nature of an AI system really depends on the amount of data they are trained on. Hence, the ability to gain good data is the solution to good AI systems in the future. But, in reality, the everyday data the institutions collect is poor and holds no significance of its own. They are biased, and only somehow define the nature and specifications of a limited number of people with common interests based on religion, ethnicity, gender, community, and other racial biases. The real change can be brought only by defining some algorithms that can efficiently track these problems.

g) Data Scarcity

With major companies such as Google, Facebook, and Apple facing charges regarding unethical use of user data generated, various countries such as India are using stringent IT rules to restrict the flow. Thus, these companies now face the problem of using local data for developing applications for the world, and that would result in bias. The data is a very important aspect of AI, and labelled data is used to train machines to learn and make predictions. Some companies are trying to innovate new methodologies and are focused on creating AI models that can give accurate results despite the scarcity of data. With biased information, the entire system could become flawed.

Conclusion

Although these challenges in AI seem very depressing and devastating for mankind, through the collective effort of people, we can bring about these changes very effectively. According to Microsoft, the next generation of engineers has to upskill themselves in these cutting edge new technologies to stand a chance to work with organizations of future and in order to prepare the youth, "upGrad" has been offering programs on these cutting edge technologies with many of our student working in Google, Microsoft, Amazon and Visa and many another fortune 500 companies. It is high time Nigerian educational system especially Nigerian University Commission (NUC) in the current CC-MAS review should make adequate provision in terms of infrastructure, data gathering, course contents and many others to meet the trend of educational development in the area of AI development. The universities should be interested to learn more about artificial intelligence and machine learning by executive PG Programme in Machine Learning and AI which is designed for working professionals and offers 450+ hours of rigorous training, 30+ case studies and assignments, 5+ practical hands-on capstone projects and job assistance with top firms.

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UTILIZATION OF E-Learning Technology for Skill Acquisition In Management And Accounting Education Programmes In Nigerian Universities

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Abstract: *The paper discussed E-learning technology for skill acquisition in Management and Accounting Education Programmes in Nigerian Universities. Skill acquisition is the ability of graduates to acquire specific skill in a certain area of human endeavour. Effective training of students in skills acquisition in areas of Management and Accounting education with e-learning facilities will provide a platform for technological excellence and redemption from economy hardship. With e-learning, students can learn at their own pace, from anywhere and at anytime. The current situations in the world calls for e-learning technology for skill acquisition in management and accounting education programmes for effective functioning in the world of work. Concepts such as skill acquisition, e-learning, Management and Accounting Education were reviewed and examine in this paper. The study concluded that skill acquisition is inevitable for any graduate who wants to succeed and get a job. Possession of appropriate skills will make graduates self-reliant, thereby creating job opportunities. Based on the conclusion of the study, it was therefore suggested among others that Federal and State governments should provide e-learning facilities in the universities for effective teaching and learning.*

Key words: E-learning Technology, Skill Acquisition, Management Education, Accounting Education

CITATION:

Usen, S. M., Goddy-Mkpa, C. P., Akpan, A. J. and Udi, A. I. (2023). Utilization of E-Learning Technology for Skill Acquisition in Management and Accounting Education Programmes in Nigerian Universities. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Professor Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp 264-269

Introduction

The twenty-first century has brought growth and improvement to Management and Accounting education in the area of e-learning technology. The rate of growth in information handling is quite alarming and has brought many benefits to education. Management and Accounting education have helped graduates of Management and Accounting education to acquire skills in specific areas. Skill as reasoned by Usoro (2016) is thought of as quality of performance which does not depend solely upon a person's fundamental, innate capacities but be developed through training, practice and experience. It is the art of possessing the ability, power, authority, or competency to do the task required of individual on the job. In order to gain employment or even create job

for others, there is need for individual to acquire skill so as to be competent and confidence which will help to promote economic growth in the society, skill acquisition is necessary, and it can be in the areas of Management education and Accounting education. In this article, the focus is on e-learning technology in Management and Accounting education programmes in University of Uyo.

Concept of Skill Acquisition

Skill acquisition is the ability to graduate with a specific skill in a certain area of human endeavor. Learners are trained with the expectation that they will graduate at the end of the programme with a particular skill. In the word of Usoro (2016), skill acquisition is a function of the method of instruction, variety of works available to the master/tutor, the quality and quantity of the tools and equipment used, duration of training and the receptivity of the methods of acquiring vocational skills. Recalling the believed of Usen, Charles and Goddy-Mkpa (2022) even rural women in agriculture in Akwa Ibom State, have acquired skills on how to clear the bush, burn, cultivate, weed and harvest as well. And, that many of the rural women practice these skills as daily job and as vocational business. Now, skill acquisition is paramount for success in life. For emphasis, the National Education objectives stated that the acquisition of appropriate skills, abilities and competencies both mental and physical are important for all Nigerians to live and contribute to the development of their society (Federal Republic of Nigeria, 2013).

Skill acquisition is the process of acquiring or gaining effective and ready knowledge in developing ones aptitude and ability in a particular field. Skill acquisition at the University of Uyo in Management and Accounting education programmes, is meant to equip students with theoretical and practical knowledge on income generating skills. Effective training of students in skills acquisition in areas of Management and Accounting education with e-learning facilities will provide a platform for technological excellence and redemption from economy hardship. As would be managers and accountants, it will expose them to acquire the needed skills for proper functioning at work place. The significance of skill acquisition as noted by Udo (2014) include, possession of skills and competencies, provision of amusement, happiness, love, affective and enjoyment to other individuals, reduction of criminal activities such as armed robbery, kidnapping and other social vices among the youths. The acquisition of skill helps to produce productive workers and employers of labour which will eventually reduce unemployment rate in the country. Skill acquisition is a highly commendable concept to address in practical the problem of unemployment which is biting hard in our country – Nigeria, because it will lead to economic growth, and emancipation to national development. This will be coupled with preparing the students through usage of e-learning.

Concept of E-Learning

E-learning is a type of learning conducted via electronic media, typically on the internet. Successful e-learning depends on the self-motivation of individuals to study effectively. It is a learning system based on formalized teaching but with the help of electronic resources. While teaching can be based on or out of the classrooms, the use of computers and internet forms the major components of e-learning. With e-learning, students can learn at their own pace, from anywhere and at anytime. Through delivery methods such as games and social media, e-learning also makes the learning process more immersive and interactive. Moreover, e-learning enables relatively faster delivery cycles. Here, Usen, Goddy-Mkpa and Essien (2020) discussed various e-learning

facilities that could be used, these include; Class Dojo, Edmodo, Google classroom, Thing-link and Schoology, Pear Desk among others.

Class Dojo: Is a tool that connects school teachers, students and families through communication features such as photos and videos from the school day and messaging that can be translated into more than 35 languages.

Edmodo: This is another e-learning tool that can be used for communication and sharing classroom contents.

Google classroom: This platform helps classes to connect remotely, communicate and stay organized. It is a free web service developed by Google for schools that aims to simplify, creating, distributing and grading assignments. Google classroom integrates documents, sheets, slides, gmail and calendar into a cohesive platforms to manage students and teachers communication.

Thing-Link: Conte (2011) wrote that in science students could create an interactive image to develop or demonstrate their knowledge about a scientific concept or topic, then Accounting education students could use Thing-link on the application of arithmetic and logical calculation in accounting courses. It can be used by Accounting Education students to acquire skills in Accounting while schoology as a form of e-learning method which could be applied to support instructions, learning, grading, collaboration and assessment. As asserted by Usen, Goddy-Mkpa and Essien (2020) the service of schoology include online grade books, test and quizzes, home word and drop boxes.

Pear Desk: This is another area of e-learning facility design to engage instructional content with various integration features. With Pear Desk, a teacher can design a new presentation or open an existing on the slides. Here library templates are created to support objectives as noted by (Root, 2014). This e-learning facility equally could be used by Management Education students to acquire management skills. Before the discussion on management skills, there is need to understand the concept of management. As written by Jibril (2012) management is the coordination and administration of tasks to achieve a goal(s). Such administrative activities include; setting the organization's strategy and coordinating the efforts of staff to accomplish these objectives through application of available resources.

Challenges of e-learning Facilities in Management and Accounting Education

In the Department of Business Education, University of Uyo, there are many students and competent lecturers. Here, students are meant to be prepared for skill acquisition in Management and Accounting Education. Unfortunately the Department lacks e-learning facilities such as Class Dojo, Google classroom, Schoology, thing-link for teaching and learning. The non-availability and utilization of these facilities have resulted to making the students in Management and Accounting Education options to graduate without the needed skills. These have created a situation whereby the graduates cannot handle Management and Accounting problems in office or other places competently. They are unable to utilize digital facilities for zoom meetings, spread sheet accounting facilities among others. Equally they are found wanting as they cannot compete with their counterparts from private universities. Hence, the lack of utilization of these e-learning facilities possess a drawback, and make them strangers when they eventually meet the facilities at their work places.

Concept of Management Education

This is a Management Education programme that prepares students to acquire skills in Management. As opined by Njoku (2007) management is a process by which co-operative group directs actions of others

toward common goal(s). Management cannot be properly exercised effectively without having the needed skills in an organization. Management skills as listed by Usoro (2016) include; decision making skill, planning, coordination, organizing, directing and communication skills.

- **Decision Making Skill:** Decision making, a good management is based on decision. It forms one of the hardest tasks of a manager. A workable policy of an organization depends solely on the decision reached by the management. It is concerned with a continuous and conscious act. Decision making involves a process of identifying and selecting a course of action to solve a specific problem in an enterprise. Therefore, it can be said that decision making helps management to explore alternatives prior to the act of choosing the one to be implemented in order to reach or achieve the organization's goal(s). Hence, to achieve this aim, students can be prepared using e-learning technology to expose them to the needed skills. These skills are discussed here;
- **Planning Skill:** Planning skill is highly necessary if the management wants to succeed. The managers are to be very calculated, set goals ahead and work out modalities to attain the goals especially where the company is a going concern. According to Njoku (2007), planning are of two broad categories;

  Strategic planning where top managers determine the general objective of the organization and the best-way of reaching the objectives, concerning the available resources and those expected to be available in future date. This type of planning will set a path-way for activities of the organization to follow. This form of planning allows the organization to stay focus even when there is changes in the economic and business environment, adjustment can be made with precision, still to arrive at success at the end of the period. On the hand;

  There is another form of planning that covers some functional areas such as Production, Marketing, Finance, Personnel Recruitment among others. There is increase technical/electronic complexity of operation and faster obsolescence of equipment which will need replacement, the management is to plan on how this situation will be handled in order to stay afloat in business. With this, management education students will need to acquire this planning skill to be competent to handle any situation. The management will equally be faced with organizing of activities in the organization. **Organizing** entails the structuring of activities, materials and personnel for accomplishing the assigned tasks. This calls for effective preparation. With the acquired **organizing skill**, the management or managers should be guided; to ensure that the plan or operations is properly executed, see to it that the organizational structure is consistent with the firm's resources and objectives, establish a competent and vigorous management that has a singleness of purpose, maintain discipline, define duties carefully and avoid excessive red tape and others. Another skill needed by management education graduates is **Coordination skill**. Coordination skill provides the requisite unity and harmony needed to attain organizational goal(s). One way to accomplish this, will be to have regular meetings of managers and seeking their opinions. Here, the management has the task to synchronize individual ideas and harmonize toward a common goal(s).

Another area to succeed is on the acquisition of **Directing Skill**. This involves giving direction to subordinates toward achievement of a common goal(s). A good manager is to possess this skill so as to bring others to see the same vision of the

organization. Without keying into the vision, there will be failure and disharmony to have direct contact with employees and reason with them and arrive at a logical conclusion, hence this type of skill is needed by Management Education students if they want to succeed as managers after school.

Mention could be made of Communication skill as one of the necessary skills for Management Education students. Obi (2005) referred to communication as the transfer of thought, desire, idea or concepts to another through talking, signs, writing and others. Communication in the organization can be orally and many times officially done through writing. Communication involves two or more parties. But, six elements are necessary for interpersonal communication, the sender, receiver, message, channels, feedback and noise. The last (noise) refers to any interference with the normal flow of understanding from one person to another. Management cannot be achieved without smooth flows of information, hence communication skill is needed by management education students when they become managers of establishment.

Concept of Accounting Education: This is an Accounting Education programme that prepares students to acquire skills in Accounting. Notably, Accounting Education graduates are to acquire Accounting Skills to be able to function effectively and efficiently in an organization. In this regards, Usoro (2016) stated the following Accounting education skills:

(a) Book keeping skill, Bank reconciliation skill, c) Imprest management skill d) Financial reporting skill, e) Auditing skill f) Tax computation skill g) Information technology skill. Also Jibril (2012) enumerated the following skills; I) Knowledge of Accounting practices ii) Proficiency in Accounting software iii) Ability to prepare financial statements iv) Ability to analyze data v) Critical thinking skills

The above listed skills indicate that the Accounting Education graduates are to acquire these skill for employment. They are to possess the skill on how to **keep proper books of account** so that management can know the financial position of the organization at every accounting period. So, it is with **Bank Reconciliation.** This involves the ability of the employee to reconcile the cash book entries with the bank and cheque transactions so as to get the correct financial position at the end of the month.

Imprest is an amount of money given to an officer for the running of the office and to retire the amount monthly to the accountant. It is expected that the officer in-charge possess imprest management skill so that the available fund is judiciously used for it purpose. **Financial reporting skill** entails the ability of the accountant to give correct and standard report according to Generally Accepted Accounting Principle (GAAP). This will guide the accountant to give authentic and reliable financial report which will help management to take informed decision.

Another area is to acquire **Auditing Skill**, this skill will help at work place to verify or examine the books of account and to give opinion with regards to the accounting system, internal control, handling and posting of transactions in the books, to detect fraud and error and give a true and fair view. Government collects different forms of taxes. Therefore, the Accounting Education student, at graduation needs to acquire **tax computation** skill so as to help the organization to pay the correct tax not more or less.

Now, information technology is highly important. The accountant in a company needs to have proficiency of accounting software. Many accounting packages example spread sheet, quick book, sage 50 peach tree, tally among others, will assist the accountant to

prepare and post items with ease. The knowledge of these electronic gadgets will assist the accountant to analyze the available financial data faster and on time. Also, it is expected that the person who occupies a highly sensitive position as accountant will certainly possess **critical thinking** skill. This skill cannot be ruled out as is expected that implementation of financial decisions rest on his/her shoulder for fruitful result and achievement of the organizational goal(s). Therefore, different ways will be explored for investment, how and where to purchase raw materials at a low cost for effective and efficient management of finances for the survival of the organization.

Conclusion

Skill acquisition is inevitable for any graduate who wants to succeed in this global competitive environment where skills are highly appreciated by business organizations. Possession of appropriate skills will make the graduate self reliant, thereby creating job for themselves and others. E-learning is a type of learning conducted through electronic media, typically on the internet and the application of e-learning as a concept require certain skills like skill in Management and Accounting Education. As a result of this, business educators should expose students to those skills that would make them good managers and accountants after graduation and students on their parts are expected to make themselves available for teaching if they actually want to excel in today's world of work.

Recommendations

1. Federal and State governments should provide e-learning facilities in the Universities for effective teaching and learning.
2. Students of Management and Accounting education should make effort to acquire the right skill that will make them salable in organizations.
3. NGOs and philanthropists should support universities with the provision of e-learning facilities that will aid in teaching and learning.
4. Business Educators should expose students to the needed skill that will make them excel in different organizations they find themselves.

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Influence of Socio-Demographic Variables In Utilization of Green Parks In Uyo Capital City, Akwa Ibom State

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Abstract: *The study investigated the real-time users of the Green Parks within the Uyo Capital City of Akwa Ibom State to determine if there were variations in the level of patronage of the parks based on six users' socio-demographic variables of gender, age, marital status, level of education, employment status and income. The study adopted Expo- facto research design and a convenience sampling procedure in selection of 392 respondents who gave their consents and completed the questionnaire. Data collected were analyzed using descriptive; frequency count and percentages, and inferential statistics; T-test and analysis of variance (ANOVA). Demographic characteristics of the population revealed dominance of the male (59.2%), 33 – 48 years age bracket (48.7%), married (53.3%), employed (66.3%) and earning monthly income of above ₦40,000 (56.6%). Out of the six socio-demographic variables, age, level of educational attainment, employment and income status showed significant variations in the level of utilization of Green Parks while gender and marital status showed no significant variation in the level of utilization of the green infrastructure. Higher level of education and income influenced the level of utilization of the Green Parks. The study revealed that socio-demographic characteristics significantly influenced the utilization of the facilities and the multi-functional spaces provided at the various Green Parks. Effective maintenance and provisions of facilities to attract the lesser attracted demographic group to the Green Parks was recommended.*

Keywords: Green Parks, Park Utilization, Nature-Based Solution (NBS), Tourists, Socio-Demographic

CITATION:

Daniel, K. S., Udofia, S. I. and Akpabio, I. A. (2023). Influence of Socio-Demographic Variables in Utilization of Green Parks in Uyo Capital City, Akwa Ibom State. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Professor Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 712-719

INTRODUCTION

Green Parks (GPs) are open, public or private areas mostly covered with vegetation, either directly or indirectly accessible to urban populations (Nova, 2016). They are defined as natural, semi-natural or planted spaces reserved for human pleasure and leisure or for the protection of wildlife or natural habitats (Sadeghian and Vardanyan, 2015; Šiljeg *et al.,* 2018). Green Park has become an important policy initiative in many cities internationally, and is being used to address a variety of environmental and social concerns today (Wolf and Madison, 2012; Udofia *et al.,* 2018). Some of such concerns are: landscape architecture and urban beautification; ecological stability like preserving natural balance/visual appearance, maintenance of healthy urban environment through provision of clean air, improving the

urban climate, unique support system for diversity of flora and fauna which enable dwellers to have access to nature; recreation avenue including physical, psychological and mental health rehabilitation; educational instructions and resource; economic; social contact and ecotourism (Baycan-Levent and Nijkamp, 2004; Daniel, 2021).

Green Parks are commonly found within or adjacent to urban built-up areas (Maruani and Amit-Cohen, 2007) and form a part of nature-based solution (NBS) projects which concept are actions inspired by, supported by or copied from nature with the aim to help societies address a variety of environmental, social and economic challenges in sustainable ways (EC, 2015; Baur *et al.,* 2016 and Kabisch *et al.,* 2016). Historically, the working classes were among the main target users for the development of parks in the United States (Burdge, 1969; Takyi *et al.*, 2018). The development dates back to the ancient times of the boulevard systems in Minneapolis and Kansas City. From 1859, when Frederick Law Olmsted, Calvert Vaux and over 3,000 workers established Central Park at the United States of America, a wave of enthusiasm for urban pleasure grounds swept across America and the world over (Harnik, 2003). In Akwa Ibom State when basic layout of the Uyo Capital City (UCC) was done, provision was made originally for 12 Green Parks/Green spaces in its master plans which were: City Park, Zoo, Arboretum, Golf Course, City square/cenotaph, two Stadia and five cemeteries (UCCDA, 2007). However, conscious establishment of Green Parks started in 2000 within the Uyo Capital City Development Authority and has been ongoing by subsequent governments (Akpan-Ebe *et al.,* 2013 and Udofia *et al.,* 2018) giving rise to Ibom Golf Resort, the Unity Park, Discovery Park, Ibom Plaza Park and the Climate Change Summit Recreational Park (Goodluck Jonathan Boulevard Park).

Although all the Green Parks provide important space-filling elements in shaping the form and layout of the city, they are however not uniform goods with continuous scale of quantity, but rather hierarchies of distinct goods which provide a range of services that enable people of different socio demographic background to meet their recreational activities. In other words, the Green Parks receive different categories of visitors with diverse intentions at different and even the same point in time. Studies in some climes have identified socio-demographic variables as one of the attributes that influences the utilization of parks. For example, patterns of park utilization are affected by different population groups of users, such as age (Liu *et al*., 2017; Wang *et al*., 2021; Ma *et al.,* 2022), income level (Wang *et al*., 2015; Marquet *et al*., 2019), education (Gu *et al*., 2020; Ma *et al.,* 2022) and gender (Maller *et al*., 2006; Ma *et al.,* 2022). The aforementioned do not provide an explicit situation across all park locations and cities. To the authors' knowledge, there is no literature review nor empirical study on how socio-demographic factors affect use and visitation of green parks in Uyo capital City (UCC). This study therefore investigated to know the composition of the users of the Green Parks in UCC and explore if there were significant variations in the levels of patronage (utilization) based on socio-demographic variables (gender, age, marital status, level of education employment status and income) of the park users.

Methodology

The study was conducted within the Uyo Capital City (UCC), Akwa Ibom State. The study area lies between latitudes 4°55'30" and 5°7'30"N, and longitudes 7°51'0" and 8°20'30"E and covers an area approximately 366km^2 in eight local government areas (AKMoED, 2014). The study area has a tropical climate marked by two distinct seasons namely, dry season (November – March) and wet season (April – October). The annual temperature range between 23.32^0 C to 31.29^0 C while the average monthly relative humidity ranges from 71 percent to 88 percent annually (AKMoED, 2014). The study adopted Expo-facto research design and a convenience sample sampling procedure (Jeuring, 2017). Out

of the 600 park visitors approached, 450 consented to take part in the study but only 392 completed copies of the questionnaire constituted the study population. Data collection was made for three months in the rainy season (July 2019 – September 2019) and three months in the dry season (December 2019 – February 2020) and the survey ran concurrently at the five GPs for consecutive two hours in the morning (7- 9am), afternoon (12 – 2pm) and evening (4 - 6pm) to ensure face-time sampling of the various facade time users. Descriptive statistics and inferential (T – test and ANOVA), were used to analyze the collected.

Results and Discussion

A. Socio-demographic Characteristics of the Users of Green Parks in UCC

Breakdown of the 392 respondents based on socioeconomic characteristics (Table 1) showed that 59.2% were male, 48.7% were of age 33 – 48 years old as against 43.6% who were between 17 – 32 years. About 53.3% of the population were married while 46.7% were either single, divorced or widowed. 80.1% of the sampled population had acquired some form of education up to the tertiary level. Also, the majority (over 90%) of the respondents professed Christianity. Although indigenes of Akwa Ibom State constituted majority (72.7%) of the sampled population, while 27.3% were non-indigenes from 22 out of the 35 States of Nigeria and the Federal Capital City (FCT). Those who visited the parks from outside the State or residing outside the UCC were 19.6% of the sample population.

The distribution of respondents with regard to demographic characteristics (age, marital status and level of educational attainments), showed inclusiveness in utilization of the urban green infrastructure.

Interestingly, the high proportion of those who have acquired some levels of education showed the extent to which the educated population were aware of the various benefits derived from interfacing with the environment for healthy living.

Table 1: Distribution of respondents according to their socioeconomic characteristics

Variables	Frequency (n = 392)	Percentage (%)
Sex		
Male	232	59.2
Female	160	40.8
Age		
17-32	171	43.6
33-48	191	48.7
49-64	30	7.7
Marital status		
Single	175	44.6
Married	209	53.3
Divorced/separated	3	0.8
Widowed	5	1.3
Educational Level		
Non-formal Education	5	1.3
Primary Education	6	1.5
Secondary Education	67	17.1
Tertiary Education	314	80.1
Religion		
Traditional	6	1.5
Islam	16	4.1
Christianity	370	94.4
State of Origin		
Akwa Ibom	285	72.7
4 Other South-South States	53	13.5
5 South East States	27	6.9
6 South West States	14	3.6
3 North Central States	2	0.6
3 North West States	9	2.3
1 North East States	1	0.3
Residential Status		
Resident	315	80.4
Visitor	77	19.6
Employment Status		
Student	85	21.7
Unemployed	47	12.0
Employed	260	66.3
Monthly Income (N'000)		
1,000 - 20,999	99	25.3
21,000-40,999	71	18.1
41,000-60,999	54	13.8
61,000-80,999	28	7.1
81,000-100,000	27	6.9
Above 100,000	113	28.8
Nature of Visit		
First time	102	26.0
Repeat visit	290	74.0

With regard to State of origin, the profile of the respondents revealed a good geospatial

distribution of tourists' experience to the ecotourism infrastructure in UCC. With one fifth of sample respondents visiting the Green Parks are from outside the UCC, it revealed a good patronage by non-resident population. These results agreed with Kabisch *et al.*, (2016); Baur *et al*., (2016) and Park and Song (2018) reports that Green Parks were utilized by people of different sociodemographic backgrounds as one of the nature-based solution projects.

Further revelation in Table 1 was that over a half of the visitors' population (66.3%) were gainfully employed with over 56.6% earning monthly income of above ₦40,000, inclusive of the 28.8% that earned over ₦100,000. This implied that most of the users of the Parks were economically better-off, earning monthly income above the national minimum wage of ₦30,000 (NMWA, 2019). Hence, 74% of them were either repeaters or frequent visitors to the parks. The result was similar to Takyi *et al.* (2018) who reported that more than half of the survey respondents at Stanley Park and Queen Elizabeth Park in Canada were employed. It also validated Burdge (1969) who reported that individuals with higher occupational status have the greatest variety of leisure activities.

B. Variations in Student's Sensitivity to Urban Forestry Based on Socio-demographic

In order to ascertain the levels of Green Park Utilization by users based on their socioeconomic characteristics, the study adopted t –test and analysis of variance (ANOVA) on the six selected socio-demographic characteristics of the sampled tourists. The variation in mean level of utilization by gender is presented in Table 2. It showed the male gender had a greater mean index than the female. However, the t-test value was 0.074 while significant value (0.941) was greater than the P-value (0.05). Thus, statistically not significant. Implying that there were no significant differences in the levels of Utilization of Green Parks in the study area due to the gender of respondents. On the marital status of the users (Table 3, item 2), the variation across its categories showed no regular pattern in the mean index. Despite the differences in their mean index, with the divorced/ separated exhibiting higher level of utilization, the significant value (0.497) was greater than the P-value (0.05). Thus, not statistically significant, meaning that there were no significant differences in the levels of utilization of Green Parks in UCC based on the marital status of the visitors. Unlike in Tanzania where gender and marital status were significant determinants of the likelihood of use/visit to urban amenity (Tibesigwe *et al.* 2018), the scenario is different in UCC as this study showed that there was no significant difference in the levels of utilization of Green Parks in UCC due to gender or marital status. The results implied that male and female, as well as single, married, divorced/separated or widowed, shared equal levels of Green Park usage in UCC. These were evident during the survey where couples and singles were seen hanging out for recreation, partaking at events or doing exercise at the various Green Parks.

Table 2: T – test results of Green Park utilization based on gender of users

GPU index	N	Mean valuation index	t-value	Significant value	P value
Gender			0.074	0.941	0.05 NS
Male	232	0.6477			
Female	160	0.6461			

With regard to age of the park users, the respondents exhibited different utilization levels with a clear pattern in their mean index across the three age grades as depicted by Item 1 in table 3. The pattern showed an increasing index with increase in age. Those within 49 - 64 years

old exhibited higher levels of utilization of the Green Parks than those in the 33- 48 and 17 – 32 age grades. Further test revealed that there was a statistical significance in the levels of utilization of the Green Parks in the study area based on the ages of visitors, as significant value (0.001) was less than p-value (0.05). On the educational attainment (Item 3), the variations across the categories showed no regular pattern in the mean index, even though all the categories showed differences in their mean index. However, Duncan mean separation placed those with no formal education in the same group with those who had acquired secondary school education.

Table 3: Analysis of variance (ANOVA) of Green Park utilization based on selected socioeconomic characteristics of user

SN	GPU index	N	Mean utilization index	F-value	Significant value	P value
1.	**Marital status**			0.796	0.497	0.05 NS
	Single	175	0.6356			
	Married	209	0.6559			
	Divorced/ separated	3	0.7745			
	Widowed	5	0.6000			
2.	**Age**			6.817	0.001	0.05 S
	33 – 48	191	0.6734^{ab}			
	49 – 64	30	0.7127^{b}			
3	**Level of Education**			3.801	0.010	0.05 S
	Non-formal Edu.	5	0.5529^{ab}			
	Primary Edu.	6	0.4559^{a}			
	Secondary Edu.	67	0.6027^{ab}			
	Tertiary Edu.	314	0.6617^{b}			
4.	**Employment status**			3.972	0.020	0.05 S
	Student	85	0.6211^{ab}			
	Unemployed	47	0.5870^{a}			
	Employed	260	0.6664^{b}			
5	**Income (₦)**			10.778	0.000	0.05 S
	0 – 20,999	99	0.5969^{a}			
	21,000 – 40,999	71	0.6193^{a}			
	41,000 – 60,999	54	0.5828^{a}			
	61,000 – 80,999	28	0.5956^{a}			
	81,000 -100,999	27	0.6253^{a}			
	Above 100000	113	0.7572^{b}			

Those with tertiary education however had the highest mean index. Despite the mean index grouping mentioned above, the significant value (0.010) was less than p-value (0.05) making the variation statistically significant. Thus, there were significant differences in the level of utilization of the Green Parks in the study area based on educational attainment of users. The import of these results is that age and additional educational attainment must have informed the

visitors of the need, how, when and which of the Green Parks they should visit. This corroborated Tibesiqwa *et al.* (2018) who reported that users in the mid-level of education (11–14 years of schooling) were more likely to visit urban Green Parks than the less educated ones (0 – 10 years of schooling). It also agreed with Ikawa (2015) who reported that the level of education affected the type of space visited, indicating social and political differences in access.

The respondents also exhibited different levels of utilization of the Green Parks in UCC based on their employment status (Item 4) though with no regular pattern in their mean index across the three categories. Those who were employed exhibited more level of utilization of the parks than those who were students and unemployed. The result revealed statistical significance, as significant value (0.020) was less than P-value (0.05). On income level of the park visitors (table 3, item 5), there were variations in mean level of utilization according to their financial earnings. Those who earned above ₦100,000.00 exhibited greater level of utilization of the urban infrastructure than those who earned ₦100,000.00 and less. Though there was no regular pattern in the mean index, the result revealed statistical significance, as significant value (0.000) was less than P-value (0.05). Empirically, employed users with higher income status more than the unemployed ones with lower income status. This may not be unconnected with the use of the space to unwind (relaxation with friends) and ease of stress and boredom as reported by Heidt and Neef (2008). These findings are similar to Takyi *et al.* (2018) report that more than half of the survey respondents at Stanley Park and Queen Elizabeth Park in Canada were employed, as well as Pussella and Li1 (2019) and Tibesigwe *et al.* (2018) who reported income as one of the determinants of visitation to urban parks and other green recreational spaces in Sri Lanka and Dar es Salaam, Tanzania, respectively.

Conclusion and Recommendations

It is important to have a good knowledge of who uses public space like the green parks. Responses of the 392 different time façade users of the five green parks in Uyo capital City gave an insight to the patronage of the infrastructure. Compared to female gender, the male dominated the users' population and the employed who earned income above the national minimum wage, were the frequent visitors to the facilities. The results highlighted that there exists a relationship between the socio-demographic variables and the utilization of the green spaces giving reasons to concluded that the representation of many socio-demographic characters attested to the inclusivity of the facilities and the useability of the multi-functional spaces provided at the various parks. Effective maintenance and provisions of facilities like park benches, vendor outlets and reliable security service, is recommended to attract the lesser attracted demographic group to the facility.

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Impact Of Petro-Politics On Nigeria's Economic Sustainability

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Abstract : *The goal of this article is to identify and discuss the political issues related to Nigeria's Petroleum Industry, as well as X-ray the degree to which oil and gas operations have improved Nigeria's socio-economic sector, analyze residents' living conditions prior to the implementation of sustainability programs and examine how such programs have impacted Nigerians' quality of life in the light of the current issues of conflicts, corruption and natural resource depletion. The objective of this study is to evaluate selected available resources on the influence of politics on petroleum activities in Nigeria. The rentier effect, modernization, lootability, and grievance theories are central to the concept of oil and gas resource politics. This research involved samples and presentations that formulated the procedures of problem identification, searching for relevant literature, data evaluation and analysis, which premised on an integrated literature review. The study employed Google Scholar, Academia, Research Gate and Semantic Scholar to look for published articles between 2019 and 2023. These were acquired, sorted out based on similarities and differences having passed the inclusion criteria and quality checks using critical appraisal tools. These analyses demonstrate that Nigeria, as a petroleum-producing country, faces issues of substantial oil/gas money and petropolitics; thus, it mimics Petropolitics in countries like Norway and Qatar. Consequently, future studies on the position that segregates petroleum and energy resource earnings in emerging petroleum-producing countries from the role of the ruling political class should be considered by oil politics experts.*

Keywords: petro-politics, sustainable development, integrated review, black gold, corruption, economy

CITATION:

Isang, U. and Asuquo, J. E.(2023). Impact of Petro-Politics on Nigeria's Economic Sustainability.IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 702-711

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INTRODUCTION

The resource scourge, a phenomenon wherein political actors can use mechanisms to actualize massive corruption and the state's status as a "wealthy elite," is often blamed for the comparatively slow rate of growth and development in Nigeria. Understanding the barriers to sustainable development and governance failure depends on the impact of resource control and income allocation by the political elite on fundamental democratic systems. The main issue is whether and how to break out of a bad baseline despite a half century of oil and gas exploration and production in Nigeria, given that issues with petroleum

industry governance are deeply ingrained in Nigeria (Ugwuja *et al., 2015*). In order to analyze the political influence on the petroleum industry value chain and the elements of sustainable development, which are environmental, social, economic and human development, this research adopts a political economy perspective (Chinjenge & Roosa, 2022). This study attempts to investigate contemporary issues surrounding the impact of petropolitics on Nigeria's economy and sustainable development, as well as the major political and economic aspects of Nigeria's black gold sustainability.

The current financial and macroeconomic occurences in Nigeria's economy expanded by 3.6 percent in 2021 after contracting by 1.8 percent in 2020, supported on the supply side by a 4.4 percent increase in non-oil production versus an 8.3 percent decline in the oil sector. Agriculture (2.1%) and services (5.6%) contributed the most to the non-oil sector. Both public and private expenditure boosted GDP on the demand side. In 2021, the per capita income rose by 1.0%. Due to a small increase in receipts, the fiscal deficit decreased from 5.4 percent of GDP in 2020 to 4.8 percent of GDP in 2021, with borrowing used to cover the difference. In 2021, the public debt was $95.8 billion, or around 22.5% of GDP (www.afdb.org).

In 2021, annual average inflation rose to 17.0% from 13.2% the previous year above the central bank's target. Due to persistent politics in policy formulation, corruption and implementation, increased insecurity has resulted in low oil production, and growth will slow averaging 3.2 percent from 2022 to 2023. Inflation is anticipated to remain high in 2022 at 16.9% and to remain beyond pre-pandemic levels in 2023, driven primarily by rising food, fuel, and gas costs as well as ongoing supply disruptions made worse by the conflict between Russia and Ukraine. While oil production is anticipated to modestly rise, capital inflows are expected to recover. However, the expected positive impact of the oil price changes on exports may be somewhat offset by a poor output effect caused by decreasing oil production, which is fueled by inadequate infrastructure and increased insecurity. (www.worldbank.org).

The country's hyper-corruption and widespread poverty are caused by the localization of corruption, the emergence of strong cabals, and machine politicians. Additionally, this leads to a rise in potent armed militias and criminal gangs, as well as horizontal and vertical inequality. The revelation that lawmakers had tasked President Muhammadu Buhari with combating oil thieves, whom they claimed had launched a war on Nigeria, was one of the headlines in the ThisDay newspaper's issue of Saturday, October 8, 2022. The same newspaper also revealed that a former warlord named Tompolo had uncovered security officers as participants and leaders in this criminality. Tompolo had just been hired by the Nigerian government to help stop the flow of crude oil theft in the Niger Delta. Sixteen undiscovered tapping spots on the Trans-Forcados pipeline were also revealed in the analysis. At the joint subcommittee on gas and petroleum (upstream and downstream) of the Senate, the chief executive officer of the NNPCL, Mele Kyari, revealed that Nigeria has observed an increase in oil theft in recent years. The NNPCL previously claimed that oil theft costs the nation $700 million a month, or 470,000 barrels of crude oil.

The objectives of the study are:

i. To identify and assess the political contributions made to Nigeria's oil and gas industry.
ii. To determine the extent to which oil and gas operations have enhanced Nigeria's socio-economic development.
iii. To investigate residents' living situations prior to the introduction of sustainable

development programs, as well as how these programs have affected Nigerians' quality of life.

The return to democratic rule has enhanced the distribution of capital inflows, openness and suggests that federal reforms and changes to the petroleum industry have great potential (Imobighe & Fiia, 2015). The court has also begun to regain public trust in its ability to act as a watchdog on the executive arm of government. These changes must be strengthened and institutionalized for more stability.

According to Marx and Engels, the nature of the underlying dynamics of state operations reflects both the dominant mode of production and the political class that holds sway over the state. The state serves to defend the interests of those who possess the means of production in a capitalist society as a tool of class dominance and control of resource development (Marx and Engels, 1997). Ake (1981) had numerous times shown how control—rather than possession—evolved into an important factor in peripheral capitalist regimes like Nigeria. Following the analysis by Ake above, which is also supported by other Marxist scholars and after a critical assessment of the Nigerian state, especially after the inflow of petrodollars since the 1970s, a number of scholars have characterized the Nigerian state as cruel, unresponsive and exploitative (Ake, 1981; Okowa, 2005; Okaba, 2003); unlawful, oppressive, as well as repressively captured; weak and dependent (Efemini, 2002).

Stages of development and activities in the oil and gas industries in Nigeria

Petroleum, commonly referred to as "subsurface oil" or "black gold," is a lucrative resource that makes nations and individuals wealthy. Petroleum is a Latin word that means "rock oil" (petra, or rock) and oleum, or oil (oil). The oil that originates from geological formations is what it signifies when translated directly. Petroleum occurs naturally and in a combination of gaseous, liquid, and solid hydrocarbons depending on temperature and pressure gradients. Natural gas, gasoline, naphtha, kerosene, fuel and lubricating oils, paraffin, wax, and asphalt are among the fractions of black gold that can be separated. Given how heavily dependent almost every industry is on "black gold," it is no surprise that it plays a fundamental and substantial role in world economies. Today's globe relies heavily on "black gold" as a source of energy, and nations that have access to it have witnessed significant changes in their economies and societies over time. As was already established, the first attempt to discover oil and gas in Nigeria was made by colonialists in 1908. This exploration work was halted by World War 1. After the war, exploration began again in 1937 when Shell D'Arcy (a partnership between Shell and Royal Dutch) received the only exploration license for the entire nation (Otiotio, 2014). In 1956, Oloibiri, now in Bayelsa State, saw the eventual commercial discovery of oil to great celebration. Shell D'Arcy became Shell-BP Petroleum Development Company of Nigeria Limited in the same year. When the firm actually started producing, the first-ever field began to produce 5,100 barrels per day by 1958. Nigeria reported its first oil cargo that year and ever since then, it has been producing as well as exporting black gold. For example, according to the Organization of Petroleum Exporting Countries website, Nigeria delivered 1 trillion cubic feet (Tcf) of dry gas and 1,592 million barrels a day of crude oil exports in 2022.

Sustainability Development Activities in Oil and Gas Industries

This metric and idea are known as "sustainable development (SD)." The first definition of SD comes from the Brundtland report of the UNEP in 1987, according to John Ogbonna (2022), which describes SD as "development that meets

the needs of the current generation (in their quest for development) without jeopardizing future generations' capacity to optimally meet their own needs (social, economic, human and environmental developmental needs)." SD in the "economic sense" refers to the growth of all areas traditionally linked with social, environmental, economic goods and services, such as consumerism, renewable energy and other environmentally friendly technologies (Oriakhi, 2021).

Economic, social, environmental, and human development are the four pillars of sustainable development. Our primary concern in this study is economic development. Despite its tremendous resources, Nigeria's economy is lagging behind other developing countries. What are the causes of this poor performance? What role does Nigeria's natural resources, particularly its oil revenue, play in the country's poor economic performance? What role do power, politics, and decision-making play in addressing this economic growth dilemma? In answering these questions, we define Nigeria's fundamental economic development problem as the battle to diversify the national economy away from the petroleum industry and toward informal activities of subsistence agriculture with support from sub-national organizations.

Conceptual Framework

This integrative literature study is premised around themes that concentrate on the impact of petropolitics of petroleum resources on Nigeria's economy and sustainable development. The focus of this discussion is on the concepts of petroleum economics, sustainable development, conflict, oil and corruption. The following section discusses these hypotheses.

Oil and sustainable development concepts

A variety of petroleum development hypotheses have been investigated by modern experts. Some of the most notable are observed as being relevant in Nigeria: Concept of dependency and economic decline, the rentier effect, the impact of taxation as shown in figure 1., the impact of modernization, opportunities for employment, the impact of civil society, incumbency, corruption, grievances, and the theory of Obstructability.

Concept of dependency and economic decline

This is a perspective on poor economic performance that stresses the perceived limits imposed by the world's political and financial systems. The concept of dependence and lack of development criticizes the emergence of a capitalist world order with an industrialized core and an undeveloped periphery.

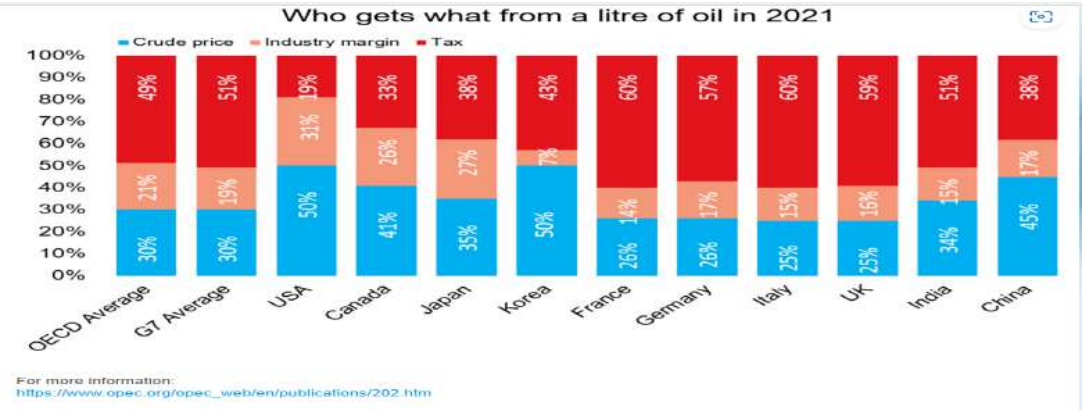

Fig. 1 Impact of taxation

Developing countries pay higher prices for finished goods, sapping money that could have been used to expand their own manufacturing capacity. As a result, a vicious cycle emerges, perpetuating the economic disparity between the affluent core and the impoverished perimeter. Despite being one of the world's largest producers of petroleum and not building new refineries, the Nigerian government continues to import petroleum products and derivatives and also pays a high subsidy on these products. Although Dangote Refinery and others are preparing to cushion the effect, we are still where we are.

Theory of Lootability—Obstructability

According to this argument, petroleum is obstructable but not lootable like other resources. It supports governments, not insurgents. Although rebels can sabotage an oil pipeline, only governments can obtain permits. This implies that rebels cannot survive on oil income (theft) but must demand money by threatening to impede (obstruct) the production of oil, as of recent, each group has a distinct function in Nigeria's oil theft trade. These main individuals employ oil bunkering techniques such as hot tapping and cold tapping to siphon thousands of barrels of oil each day from existing oil pipelines. Obstruction tactics frequently have long-term ramifications. Nigerians from a wide range of backgrounds participate in oil bunkering. These culprits include oil employees, pipeline security guards, security agency officials, NNPC officials, prominent government officials, corrupt traditional rulers and anti-state militias.

Methodology and Design of The Study

For this study, an integrated strategy was used, which aids researchers in establishing a knowledge foundation on a certain topic or field of inquiry. It suggests methods for locating and assessing information on the subject under discussion. The integrative method assists in identifying major challenges in each subject and directs scholars to the finest and most appropriate resources. By methodically examining and summarizing the literature, an integrative review of the literature identifies gaps in existing understanding and the need for future study, as shown in Table 1 (Torraco, 2005).

Problem Identification

According to extensive political economy research, economic and fiscal dependence on petroleum issues creates and influences sustainable development in Nigeria. Sarmadi *et al*. (2018) exploited this consciousness: when oil funds accrue to the state, the authority of the state administration increases since the necessity for taxes is diminished or removed, and the need for the controlling political institution to beg the public's compliance is lessened. The availability of oil and gas resources poses various problems to conventional oil-producing nations within the Organization of Petroleum Exporting Countries like Nigeria and other independent producers. Corruption, authoritarianism, civil wars, violence, and underdevelopment are all threats to the existence of gas and oil. The lower the tax level, the less motivation the people have to demand representation.

The search considered four electronic databases: academia, semantic scholar, researchgate and Google Scholar, and hand reviews of recent editions of relevant journals, magazines, bulletins, and websites. The scope of the search was limited to English-language publications between 2015 and 2023. Relevant studies were also chosen using eligibility criteria.The title and summary of each piece of writing were assessed.

Table 1: Provides an overview of the integrative review steps.

Stage	Problem Identification	Literature	Data evaluation	Data analysis	Results
Description	What is the degree of the impact of politics on petroleum resource endowments on Nigeria's rising economy administration and sustainability?	Database search: Semantic scholar, Google scholar ,Academia, researchgate	The data set contained theoretical and empirical studies.	The use of qualitative data analysis to establish concepts and categories.	Quantity ;amount and considered sufficiency of the content as well as the study design. Outcomes reported: governance quality, location, regime type and durability, and long-term economic development. Limitations: Extensive inclusion and exclusion criteria

The first of the stated criteria included research studies on the impact of politics and petroleum resources on sustainable development as well as economies endowed with those resources. Studies demonstrating one or more of the following characteristics were included:

1. Studies that established an analytic framework for implementing major investments in the petroleum industry with a focus on the connections between investors, the local populace, and the political class
2. studies that examined Nigeria's petroleum sustainability and compared it with that of other countries.
3. Studies that show the influence of oil and natural gas resources in conjunction with changing non-resource-specific contextual factors on conflict, democracy, corruption, as well as the functioning or integrity of various political institutions
4. Studies that looked into the connection between the allocation of oil and gas resources in Nigeria and the political system, governance quality, or governments' ability to deliver on economic development and sustainable development goals.

Results and Discussion

When doing an integrated review, data set is crucial. When articles use similar study designs, it is suggested that a simple grading system be used for comparative analysis among studies. Because this review includes articles that used a variety of research approaches, the literature was weighted on a five-point scale based on three criteria: yes, no and undecided which was evaluated using Kendall's coefficient of concordance (w statistic). As a consequence, the quality of relevant literature was independently assessed, decisions made and agreement was obtained on the final decision on literature for inclusion. While each study is culturally diverse, the results are valuable since they correspond to the experiences of educators in various countries observed during the research study. This review's data evaluation procedure included employing the recommended constant comparison method. The studies were assessed using the following methods: overall quality, data reduction, pattern, theme, variation, location, and relationship detection.

The qualitative analysis of the content and the statistical method were chosen for this investigation. This included reading and reviewing the articles as well as writing a quick overview using the checklist (see Table 2). Following the analysis, we created a standard critical appraisal skills tool to answer the following questions (1–10):

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Table 2: Responses on the Impact of Petropolitics on the Economy and Sustainable Development

	Weight	5	3	1	R_i	$\bar{R}$	$(R_i-\bar{R})^2$
no	Parameter	Yes	no	Undecided			
1	Did the review answer a specific question?	3	1	1	19	30	121
2	Did the writers search for the appropriate papers?	3	0	2	17	30	169
3	Do you believe all relevant and important studies were included?	2	1	2	15	30	225
4	Did the authors do enough to assess the quality of the included studies?	5	0	0	25	30	25
5	Was it acceptable to combine the results of the review?	2	1	2	15	30	225
6	Is the review's overall outcome satisfactory?	3	1	1	19	30	169
7	Are the outcomes precise?	3	1	1	19	30	169
8	Can the findings be generalized to the local population?	4	0	1	21	30	8
9	Were all key outcomes taken into account?	2	1	2	15	30	225
10	Are the positives worth the risks and expenses?	3	1	1	17	30	169
						∑	1578

$$\text{W statistic} = \frac{12\sum(\text{Ri}-\bar{\text{R}})^2}{m^2n(n^2-1)} \quad (1)$$

$$\text{statistic} = \frac{12\sum(\text{Ri}-\bar{\text{R}})^2}{m^2n(n^2-1)} = \frac{12\ x1578}{25\ x10x99}$$

$$= 0.7651 = 76.51\%$$

w*here m =total number of respondents, n=total number of objects,*

$\bar{R}$*=0.5n(m+1)* (2)

The research of the impacts of petroleum resources and politics on emerging economies revealed three key themes: outcomes-focused on the style of government system, governance quality, and governments' ability to sustain the development. Please see Table 3. The Kendall's coefficient of concordance (w statistic) tool was preferred because it demonstrates the degree of agreement between variables and can be used to assess the quality of various study designs as well as the synthesis and analysis of research findings. This evaluation was reviewed by five separate reviewers using questions 1 through 10 on the checklist, and the results for each study were summarized in table 2. Using equations (1) and (2) to calculate the w , there are five respondents and ten objects. According to the results, there is agreement among the respondents. This is due to the fact that the figure is 76.51%, which is close to 100%. Albinali (2017) and Balan (2016) investigated the feasibility of the idea that oil is a hindrance to democracy. His research yielded conclusions. Initially, it was discovered that the argument that oil hinders democracy is statistically robust and legitimate; in other words, oil does harm democracy.

Wegenast (2016) investigated institutions and the start of conflict as factors influencing the quality of politics in oil-rich countries.

Brooks and Kurtz (2012) discovered that oil is not only a burden but also assists in establishing democratic political regimes. Smith (2017). His research found that while countries most reliant on exports witnessed more protests during the collapse, neither the boom nor the bust had a significant impact on regime stability. In short, oil money enhanced regime lifespan in general, but repression had only a minimal impact. Oluniyi (2017) demonstrated the devastatingly high loss in recent national oil income, which, combined with the global drop in oil prices, has dealt the final blow to Nigeria's petroleum industry.

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Table 3: Overview of the studies reviewed.

Reference	Sample size	data collection	Aim	Findings
Albinali, A. (2017).	*oil producing countries*	*Cross-sectional data analysis.*	Investigates the link between the corporate structure and the political positioning of elites.	A smaller governing coalition substantially indicates state control of the petroleum sector.
Brooks, S. M. and Kurtz, M. (2016)	Global	Cross-sectional data analysis.	investigates the potential anomalies of oil revenue to human capital and industrial development initiatives	Alternative indicators of oil abundance but also democracy have negative connections with oil.
Ross, M. (2015).	Global	Cross sectional data analysis.	The argument that natural resource richness has a negative impact on a country's governance.	Oppressive governments last longer, promote specific types of corruption, and spark violent conflict in low- and middle-income countries.
Smith, B. (2017).	Global (1960-2009).	Cross-national data	Examine the impact of oil wealth on political system.	Oil income has a major stabilizing influence, but it is less powerful than price leverage.
Wegenast, T. (2016).	Covering 40 countries	Regression analyses	Collect data on the consequences of the resource-ownership arrangement on political violence.	Oil production could include peace-making methods such specific political patronage behaviors.
Oluniyi, A. E. (2017).	Nigeria	Cross-sectional data analysis	Nigeria's production of oil and gas and Niger Delta militants: the necessity for oil wealth to end reliance on oil for long-term development	. The devastating steep decrease in national oil revenues in recent years, along with the global decline in oil prices, has dealt the ultimate blow to Nigeria's petroleum.
Umar, *et al.*(2021).	Nigeria	Cross-sectional data analysis	Environmental, socio-economic effects of pipeline transport exclusion in Nigeria	Pipeline interdiction, on the other hand, has impacted the continual flow of crude oil.
Balan, F. (2016). .	Nigeria	Cross-sectional data analysis	On irregular causal affairs in Petropolitics.	Negative oil supply shocks significantly lead to negative political stability shocks.
Ogwus, C. (2022)	Nigeria	Cross-sectional data analysis	Sustainable Development in the Niger Delta: Interrogating the Role of Multinational Oil Corporations.	The study suggests that oil firms and their host communities work together more closely when deciding where to locate CSR projects.
Chinjenge & Roosa, (2022)	Nigeria	Cross-sectional data analysis	Influence of Petroleum on Governance of Evolving Producers.	oil and gas resources have a detrimental impact on the governance of developing producer countries.
Brown *et al.* (2022).	Nigeria	Cross-sectional data analysis	Investigation of Oil and Oil-Producing Communities of the Niger Delta	increasing recognition of the accumulative potentials of oil engendered violent conflict.
Iwuoha, V. C. (2021).	Nigeria	Cross-sectional data analysis	Comprehensive Security Planning as well as Asset Protection for Multinational Oil Pipeline Assets in the Niger Delta.	Lack of effective strategic security planning and capacity building undercuts the ability of security agencies.
Ejike, C. E. (2020)	Nigeria	Cross-sectional data analysis	Niger Delta Areas as the Post - colonialism Precariat: Mitigating the Influence of the Resource Curse	Oil wealth has ironically become a curse for localities whose substantial petroleum endowment applied to the system to national prosperity.
John Ogbonna,	Nigeria	Cross-sectional data analysis	Investigating the Critical Factors for Long-Term Development in Nigeria's Economic	Once incorporated in general sectors of the economy, company structure, and corporate social duties of the nation's respective activities, the effects will be severe.

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Umar (2021) demonstrated that the environmental and socioeconomic implications of pipeline transport restrictions in Nigeria have an impact on the continuous flow of crude oil. According to Ogwu and John's study (2022), oil companies and their host communities should collaborate more closely when determining where to locate CSR projects for sustainable development in the Niger Delta. Brown *et al.* (2022), Iwuoha, V. C. (2021), and Ejike, C. E. (2020) demonstrated that increasing recognition of the accumulative potentials of oil engendered violent conflict; a lack of effective strategic security planning and capacity building undercuts the ability of security agencies; and oil wealth has ironically become a curse for localities whose substantial petroleum endowment contributed to the system and national prosperity.

Findings

I. In democratic rule, oil wealth impedes effective governance and changes.
II. Although this influence is fragile, petroleum riches prolong the tenure of government officials.
III. Petroleum has little overall effect on democratic survival, but it may hasten democratic breakdown in low-income countries.
IV. From the coefficient of concordance of 0.7651, it showed that there was a strong agreement that this review met the criteria.

Conclusion and Recommendations

This article attempted to investigate Nigeria's petroleum industry and how it impacted the country's economy and sustainable development. The industry has undoubtedly increased the nation's GDP, but the extent and degree of politics in government have prevented citizens from feeling the petroleum phenomenon. Despite the wealth generated by oil earnings, many Nigerians still survive on less than $1 per day. The widespread corruption among the Niger Delta's elite has aided in the emergence and sponsorship of armed groups responsible for kidnapping residents and non-citizens, thus obstructing federal government efforts to develop the region's infrastructure.

Local leaders and a few powerful individuals are provided "protection contracts and jobs" by the oil corporations in order to sustain oil drilling in the area without causing disturbance. These "protection contracts," which include employment and various payments, are made by oil firms to protect oil-drilling activities from pirates and crude oil theft (bunkering) by other gangs. Contracts are also utilized to provide employment to a small number of indigenous people. Thus, the government must achieve transparency in order to resolve the aforementioned issue. The region's corruption must be addressed head-on so that its inhabitants (particularly the youth) can begin to experience the benefits of the wealth surrounding them.

Recommendation:

1. To be able to use the land properly, their environment should be free of oil spills.
2. Citizens' education is critical to the prosperity of any nation. The government needs to invest more in its citizens' education to ensure high literacy rates and cognitive ability, which will foster patriotism and responsibility.
3. The government should stabilize macroeconomic circumstances.
4. They should not upset the macroeconomy in any way. The above will also help reduce wasteful spending.
5. Oil should no longer be considered the only option for Nigeria's economic survival. The sooner the country diversifies its economy, the better for everyone.
6. All levels of government should learn to manage their budgets within the boundaries of their monthly allocations and avoid all forms of borrowing.

7. Finally, the country must increase its efforts to revive agriculture in order for it to exit parallel with the oil business.

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Breaking The Oil Curse In Nigeria: Imperative For Economic Diversification And Sustainable Development Through Agricultural Transformation

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Abstract : *It is a tragedy that Nigeria's oil wealth has failed to bring the expected economic development. Unfortunately, the country is experiencing economic stagnation and myriads of socioeconomic problems including rising levels of poverty, unemployment, inequality, conflicts, crime, corruption, and bad governance in addition to the collapse of the non-oil sectors of the economy especially, agriculture. This work, therefore, examines the possibility of breaking the oil curse in Nigeria through a process of economic diversification anchored on agricultural transformation. While offering an explanation for the occurrence of the oil curse phenomenon in Nigeria, the paper maintains that this socioeconomic malady can best be resolved using policies targeted at revitalizing agriculture and other non-oil sectors of the economy. The choice of agriculture to lead the drive towards economic diversification is supported by loads of empirical and historical evidence. It is the contention of this work that better outcomes can be achieved if development policies are targeted at transforming the agricultural sector. This can be done by increasing budgetary allocation to agriculture in order to promote investments in agro-related enterprises and to upgrade agro-related infrastructures. There is the need for policies that support the farmers with grants, inputs, credits, and loans while promoting their access to information, innovative technologies, security, capacity building, advisory services, and market. The right policy framework will engender economic diversification and the eventual termination of the oil curse in Nigeria.*

Key Words: Oil curse, diversification, development, inequality, poverty

CITATION:
Harrison, U. E.(2023). Breaking the Oil Curse in Nigeria: Imperative for Economic Diversification and Sustainable Development Through Agricultural Transformation. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 691-701

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Introduction

The discovery of crude oil in commercial quantity in the nineteen seventies was a historic event that shaped the socio-economic development of Nigeria. Oil was celebrated as a blessing, and the expectations were very high. However, oil wealth has failed to engender the much-expected economic development in Nigeria (Udeh *et al*., 2021). Rather, it has caused the collapse of the hitherto functional and promising productive sectors, especially agriculture (Oji-Okoro, 2011). According to Mahler (2010), Nigeria's oil boom brought a sudden increase in revenue inflow which produced economic stagnation and myriads of socioeconomic consequences including

increased levels of unemployment, poverty, inequality, conflicts, corruption, crime, and bad governance. Rather than yielding the expected prosperity, oil endowment has become like a curse to Nigeria (McNeish, 2010). Although much research has been done on the relationship between oil wealth and development, the ongoing socio-economic turbulence and the escalating militancy, conflicts, insurgency and general insecurity in Nigeria call for urgent action to end the jinx of oil. This work, therefore, examines this tragedy and explores the prospect of breaking the oil curse and achieving economic diversification in Nigeria through agriculture. Investments in agriculture are seen to present the surest means for Nigeria to attain the much-expected economic diversification and sustainable development.

There are historical and empirical pieces of evidence to support the assertion that the way out of Nigeria's socioeconomic predicament is diversification through the revitalization of agriculture and other non-oil sectors (Ezeh, 2009; Diao *et al*., 2010a). The call for the diversification of Nigeria's economy is rife especially given the worsening socioeconomic conditions, the rising cases of conflicts, insurgency, crime, militancy, and the appalling state of insecurity traceable majorly to the resource curse phenomenon. With a fragile and vulnerable monolithic economy, Nigeria is very susceptible to all kinds of turbulence inherent in the global economic system. Diversification into agriculture and other non-oil sectors is therefore seen as a recipe for resilience and sustainability. There is growing optimism concerning the capacity of agriculture to engender growth in a fast-globalizing world. A review of literature shows that agricultural development has served as a precondition for industrial development in many countries (Valde and Foster, 2010; Diao *et al*., 2010b; Daneji, 2011; Eko *et al*., 2013; Dastagri and Vajrala, 2018). The success story of the agricultural revolution in Malaysia, Hong Kong, and other Asian countries bears clear testimony to agriculture's capacity to engender economic development (Diao *et al*., 2010a). The choice of agriculture to drive diversification in Nigeria is very justifiable as about 70 percent of the poor are found in the rural areas where the predominant occupation is farming (Word Bank, 2007). Agriculture makes significant contributions to economic development by ensuring the supply of labour, food, and foreign exchange earnings (Chukwuma, 2018; Umeji,2019). It equally stimulates growth in other sectors of the economy (Kay, 2009).

Agricultural investments are known to generate multiple direct and indirect outcomes which are beneficial to the Nigerian economy (Oji-Okoro, 2011; Alawode and Oluwatayo, 2019). According to World Bank (2008), Nigerian agriculture has the capacity to generate income, create employment, produce food and raw materials for industries, and alleviate poverty. The Implementation Completion and Results (ICR) Report for the World Bank Assisted Third National Fadama Development Project (Fadama III) shows that the project made objectively verifiable contributions to economic development in different areas. Such contributions include: improvement in income generation and savings by farmers, creation of employment, improvement in human capacity and access to funds for investment, improvement in agricultural productivity in key agricultural value chains, improved linkages of farmers to markets, improvements in agro-related rural infrastructures, improvement in rural livelihoods, strengthening of agro-related institutions, engendering food security, gender integration and inclusiveness, among others (World Bank, 2016). Ugwu, (2007) reported

similar achievements for the Agricultural Development Programmes (ADPs).

It is the contention of this work that a lot more can be achieved if the Federal and the state governments in Nigeria are more deliberate, intentional, and systematic in targeting their development policies at transforming the agricultural sector. This can be done in many ways including increasing investments in agro-related businesses and ensuring the upgrade of agro-related infrastructures. Policies that provide support to farmers by increasing their accessibility to grants, inputs, credits, and loans while promoting their access to information, innovative technologies, security, capacity building, advisory services, and market can bring the impetus needed to improve Nigeria's economy.

The work will examine the prospect of breaking the resource curse in Nigeria and the possibility of diversifying the economy through agricultural revitalization. This examination will help to unravel the intricate tripartite relationship between oil wealth, agricultural productivity, and economic development. A proper understanding of this relationship is necessary for the preparation of a fit-for-purpose policy framework to drive the transformation of the comatose agricultural sector.

The Resource Curse Phenomenon and its Manifestation in Nigeria

"Natural resource curse" is a term first coined in 1993 by Richard Auty in his publication entitled *"Sustaining Development in Mineral Economies: The Resource Curse and Transparency"* (Auty, 1993). The term was used to explain a situation where negative influence was exerted on a country's socioeconomic sector and governance by natural resource wealth (Ross, 2015). Known variously as the "paradox of plenty" or "oil curse" (Karl, 1997), the term explains the observation where some resource-rich countries have failed to achieve commensurate economic and political development. Their economies appear to have been harmed by their overdependence on revenue from natural resources (Cater, 2014). The resource curse phenomenon contradicts conventional wisdom and the expectation that economic development should have a direct relationship with oil wealth.

Proponents of the resource curse thesis argue that some countries that are rich in natural resources are experiencing poor economic growth, poor democratic outcomes, rising levels of corruption, and conflicts compared to countries with limited natural resources (Collier and Hoffler, 2001; Sachs and Warner, 2001; Sala-i-Martin and Subramanian, 2003; IMF, 2007; Ibeanu, 2008; Mahler, 2010; Di John, 2011; Watts and Ibaba, 2011; Wennmann, 2011; Nwokolo, 2012; NRGI, 2015; Ross, 2015; Stott, 2015). Most countries have experienced growth stagnation and socioeconomic turbulence instead of the expected economic development following the discovery of oil (Humphreys *et al*., 2007). Some natural resources have been associated with negative terms like "conflict commodities", "war fuel", "blood oil", and "blood diamonds", due to their ability to precipitate conflicts, social unrest and even war in some countries (Cater, 2014). Over-reliance on oil revenue for budget financing has retarded the development of technical capacity and statecraft (Karl, 1997; Collier and Hoffler, 2001; Seda, 2005; McNeish, 2010). It is true that the wasteful and reckless tendencies of countries experiencing oil booms invariably lead them to doom.

According to Cater (2014), the resource curse phenomenon is commonly associated with high-value, 'point resources' like crude oil and diamond which require the use of costly technology for their exploitation while the large inflow of revenue goes to a few highly placed

individuals. Point resources are different from agricultural resources which are low-value, more or less renewable, and have the capacity to trigger a diffused development by generating many job opportunities (Sachs and Warner, 2001). This assertion is supported by the report by the International Monetary Fund that out of 51 "resource-rich" countries deriving at least twenty percent of their revenue from nonrenewable resources, about 29 of them are poor (IMF, 2007).

Nigeria qualifies as a prime example of a country besieged by the resource curse given its economic overdependence on oil revenue and the consequential socioeconomic problems (Collier and Hoeffler, 2001; Sala-i-Martin and Subramanian, 2003; ICG, 2006; Downey *et al*., 2010; Mahler, 2010; Bagaji *et al*., 2011; Vanguard, June 17, 2021). These manifestations of the curse are quite unfortunate. Rather than generate the expected prosperity, Nigeria's oil wealth has created a monolithic economy that has practically extinguished the agricultural and other productive sectors of the economy (Mahler, 2010; Sala-i-Martin and Subramanian, 2003).

Due to overdependence on oil and the lack of a clear agenda to diversify, the economy of Nigeria is almost spineless and vulnerable to the vagaries of local and international market uncertainties (Udeh *et al*., 2021). According to Nwokolo (2012), the intensity of conflicts in the oil-rich part of Nigeria is very high compared to the period preceding the discovery of oil. Unfortunately, oil is said to have become the greatest source of sorrow and despair to the oil-bearing communities (Ibeanu, 2008). Rather than derive commensurate expected benefits, these communities have suffered various dimensions of social disruptions as well as perverse environmental devastations (Watts and Ibaba, 2011). The manifestation of the resource curse phenomenon in Nigeria calls for effective and proactive socioeconomic policies that will engender diversification and agricultural development (McNeish, 2010).

Explaining the Resource Curse Phenomenon

Two development theories seem to offer the most appropriate explanation for the resource curse phenomenon in Nigeria. These are the Dutch Disease and the Rentier State Theories.

Dutch Disease Theory

The term "Dutch disease" is used to describe the state of the Netherlands' economy immediately after 1959 when large quantities of natural gas were discovered (Di John, 2011). Tragically, the sudden inflow of huge revenue from gas resulted in the destruction of the productive sectors of the Netherlands' economy, including agriculture and manufacturing. The term is now used to describe a situation where an economy experiences negative consequences following sudden inflow of funds (Brinčíková, 2016). Such inflows usually cause currency appreciation and a reduction in the price competitiveness of other products on the export market. This makes imported goods cheaper while slowing down industrialization. With this, there is a drastic reduction in the incentive to invest in growth-promoting activities in the productive sectors.

This model predicts that structural changes usually follow an oil boom that inevitably results in the collapse of agriculture and industrialization. This happens when effective policies are not put in place to regulate the economy and provide protection to vulnerable sectors. In the case of Nigeria, the sudden fund inflow during the oil boom in the 1970s generated structural changes that eventually caused the destruction of agriculture and industrialization (Mahler, 2010). In spite of this state of affairs, this work joins Neary and Wijnbergen (1986) in contending that Nigeria can escape from this conundrum if appropriate economic stimuli are provided to engender

diversification focusing mainly on the agricultural sector.

Rentier State Theory

This theory explains a situation where the state relies majorly on individuals, business concerns and other governments for its revenue (Mahdavi, 1971). In a rentier state, at least 40% of the revenue is made up of economic rents (Beblawi, 1987). Due to the absence of incentives and an unhealthy dependence on rent for income, a rentier state does not make reasonable economic and political progress. Income from rent usually comes from resource ownership and therefore entails little effort. Resource rents generate "free incomes" and eliminate the need to generate revenue through taxation. This state of affairs does not make the government accountable to its citizens (Ross, 2015).

In a rentier-state, the huge funds generated by oil are often wasted on interventions that do not trigger growth. For instance, Nigerian politicians often formulate policies that serve political purposes rather than promote growth. In this scenario, corruption is encouraged while accountability is abandoned due to the weakening of regulatory institutions of the state (Beblawi and Luciani, 1987). It is argued that countries like Australia and Norway were able to develop in spite of their resource riches because their mineral windfall came after they had already developed "strong" bureaucratic institutions which ensured proper management of the resource rents (Di John, 2011).

The Dwindling fortune of Agriculture and The Ascendency of the Oil Monolithic Economy in Nigeria

Before the discovery of oil, agriculture was clearly the major contributor to Nigeria's economy. For instance, as of independence in 1960, agriculture accounted for about 80% of the gross domestic product (GDP), 85% of the earnings from foreign exchange, and employed up to 90% of the citizens (CBN, 2010). With the neglect of agriculture following the discovery of crude oil in the 1970s, things changed rapidly such that there was a sudden rise in the percentage contribution of oil to Nigeria's revenue from 26.1% in 1970 to 77.4% in 1975, and then to a peak of 88.6% in 2006 (Lugman and Lawal, 2011; Umeji, 2019). As shown in Table 1, there was a sudden surge in oil revenue from 166 million Naira in 1970 to 4 billion Naira in 1975. This increased further to a staggering figure of 6.5 trillion Naira in 2008. Still, this figure is quite small compared to the over USD418.544 billion made in oil revenue from 2010 to 2019, with about USD34.22 billion earned in the year 2019 alone (Vanguard, June 17, 2021).

As shown in Table 2, the component of oil in national export rose rapidly from 11% in 1963 to 99% in 2000. This shows the prominent position that oil has attained in Nigeria's export and the economy. With this over-dependence on oil, the economy is continually exposed to the vagaries of the international oil market. From Tables 1 and 2, it is clear that the staggering revenue from oil came at the expense of agriculture whose fortune continues to be on a downward spiral (Mahler, 2010; Odetola and Etumnu, 2013). This paper argues that this trend can be reversed using the right mix of economic and agricultural policies.

Table 1: Contribution of Oil to Nigeria's Total Revenue

Year	Oil Revenue (Billion Naira)	Non-oil Revenue (Billion Naira)	Total Revenue (Billion Naira)	% of Revenue
1960	0.00	0.22	0.22	0
1965	0.00	0.65	0.65	0
1970	0.17	0.47	0.63	26.1
1975	4.27	1.24	5.52	77.4
1980	12.35	2.88	15.22	81.1
1985	10.92	4.13	15.05	72.5
1990	71.89	26.22	98.10	73.2
1995	324.55	135.44	459.99	70.5
2000	1,591.68	314.48	1,906.16	83.5
2005	4,762.40	785.10	5,547.50	85.9
2006	5,287.57	677.54	5,965.10	88.6
2007	4,462.91	1,264.60	5,727.50	77.9
2008	6,530.60	1,336.00	7,866.59	83.4
2009	3,191.94	1,652.65	4,844.59	65.9
2010	5,396.09	1,907.58	7,303.67	73.9
2011	8,878.97	2,237.88	11,116.90	79.9
2012	8,025.97	2,628.78	10,654.75	75.3
2013	6,809.23	2,950.56	9,759.79	69.8
2014	6,793.82	3,275.03	10,068.85	67.5
2015	3,830.10	3,082.41	6,912.50	55.4

Source: CBN Statistical Bulletins

Table 2: Petroleum Exports as Percentage of Total National Exports in Nigeria

Year	1963	1965	1970	1975	1981	1991	2000	2006	2010	2013	2015
Percentage	11	26	58	93	97	97	83	89	73	70	55

Source: CBN Statistical Bulletins

The Imperative for the Diversification of Nigeria's Economy

Generally, there is a consensus on the urgent imperative to break the oil curse in Nigeria through economic diversification (Uzonwanne, 2015; Ozeh, 2017; Udeh *et al*., 2021). Basically, economic diversification involves the transformation of a single-income economy into one with multiple income sources with or without a resultant increase in aggregate output over time. A diversified economy is highly recommended at this stage of Nigeria's development given its potential in generating employment, banishing poverty, and guaranteeing sustainable growth and development. The call for diversification has become more strident in the face of the current global economic turbulence accessioned by covid-19 pandemic. Given the fluctuation in oil prices and the unpredictability surrounding

market trends, economic diversification remains the best and perhaps the only option that guarantees Nigeria's growth especially, in the long term (Ozeh, 2017).

The benefits of diversification are many. According to Udeh et al (2021), it minimizes economic risks, generates returns, preserves capital, and serves as an important pre-requisite for the achievement of sustainable economic growth. In a diversified economy, competition between and among the different sectors of the economy is promoted which ultimately increases productivity while ensuring social inclusiveness, broad-based participation, prudence, and sustainable growth (Di John, 2011; NRGI, 2015). Through diversification, the jinx of Nigeria's helpless overdependence on oil revenue can be broken. It remains the best option to deal with economic rentierism and other socio-economic maladies often associated with resource wealth (Akpan, 2009).

In the consideration of Ozeh (2017), there are five significant benefits derivable from the diversification of Nigeria's economy. The first is the attainment of economic stability to provide insulation against the vagaries of the international oil market. This stability prevents inflation while guaranteeing sustainable economic growth. The second is job creation to provide a solution to the problem of unemployment which is worsening every year. Diversification opens up avenues for employment in the non-oil sectors. The third is the importance of preparing the economy to be less dependent on oil as the country's petroleum reserve is fast depleting and will someday run out being a limited resource. The fourth is the decreasing demand and relevance of oil as countries are turning to more efficient, cheaper, and cleaner energy sources like solar, nuclear, geothermal, wind, water, oil sands, and shale, among others (Udeh et al, 2021). For instance, the ongoing global revolution in the use of electric cars is drastically reducing fuel consumption with serious implications for Nigeria if it fails to diversify its economy. Finally, diversification reduces poverty, improves living standards, and eliminates starvation (Tonuchi and Onyebuchi, 2019).

The Prospect of Agriculture in Achieving Economic Diversification and Sustainable Development in Nigeria

For several empirical and historical reasons, this paper sees agricultural transformation as presenting the best prospect for Nigeria's effort to break the oil curse (Oji-Okoro, 2011). Being the predominant occupation in Nigeria employing about 70% of the population, agriculture is reckoned to have the capacity to lead the drive for diversification. Additionally, Nigeria is enormously blessed with factors that promote agricultural endeavours such as favorable climatic conditions, vast arable land, water, and human resources (Chukwuma, 2018). Empirical research has confirmed the capacity of agriculture to transform developing economies through poverty reduction, job creation, income generation, capital formation, food supply, increased savings, reduction in income inequality, provision of raw materials to industries, and contribution to foreign exchange earnings, among others (Veltmeyer, 2009; Valde and Foster, 2010; Ikhelowa, 2011; Omorogiuwa, *et al.*, 2014; Oyakhilomen and Zibah, 2014; Dastagiri and Vajrala, 2018; Umeji, 2019).

Investing in agriculture in Nigeria has made significant contribution to national development by improving the Gross Domestic Product (GDP) (Oji-Okoro, 2011). Chukwuma (2018) reported that comparatively, the agricultural sector makes more contribution to the GDP of Nigeria than the petroleum sector, and that Nigeria's GDP benefits significantly from Foreign Direct Investment (FDI) in agriculture. Therefore, it may be argued that Nigeria's low GDP is a direct

consequence of the dwindling investment in agriculture.

Compared with the oil sector, agriculture employs more unskilled labour, especially among the youth and women who are the most marginalized in society (Umeji, 2019). Investments in agriculture help in developing its value chains of production, processing, storage, and marketing which create further avenues for employment and poverty alleviation (Umeji, 2019). Unlike oil production which is elitist requiring high level technology and huge finance, agricultural production characteristically allows broad-based participation. Accordingly, in the field agriculture, one finds all kinds of practitioners including the poor and the rich, the subsistent and commercial farmers, the urban and rural dwellers, the educated and uneducated, the young and the old, men and women, and even the physically challenged.

Agriculture is majorly rural-based in Nigeria and any investment targeted at improving the agricultural sector will also transform livelihood in the rural area where the majority of the poor resides. Also, the provision of rural infrastructure to support agriculture brings positive change in the living standard of the rural poor. In a way, agricultural development is akin to rural development as the objectives of the two overlaps greatly and it may not be possible to achieve one without the other.

Being one of the basic human needs, food is more critical to Nigerians than oil. In other words, Nigerians do not eat petroleum but food. Therefore, the transformation of the agricultural sector in Nigeria will achieve the dual purpose of ensuring food sufficiency and increasing productivity (Shekwo and Nnabuenyi, 2020). Agriculture has the potential to reduce inflation, support the growth of agro-dependent industries and increase foreign exchange earnings (Umeji, 2019). As aptly observed by Tonuchi and Onyebuchi (2019), agriculture can provide the springboard to catapult Nigeria into industrial and economic development (Diao *et al*., 2010a).

Conclusion

This work examined the tragedy of Nigeria's oil wealth and the prospects of relying on agriculture to engender diversification and sustainable development that will break the oil curse in Nigeria. Instead of the expected economic prosperity, Nigeria is seen to experience stagnation, conflicts, penury, and misery in addition to other forms of socioeconomic maladies including worsening fortune in of agriculture. Although the "resource curse" phenomenon has become a serious development challenge, this work argues that the malady is both preventable and curable through the use of the right development policies.

The Dutch disease theory and the rentier state theory were adopted to offer explanations for the occurrence of the resource curse in Nigeria. The former draws a parallel with the situation in the Netherlands following the discovery of oil whereby the incentives for agriculture and other primary productive activities were eroded due to the huge sudden inflow of external oil funds. The latter based its explanation on the tendency of resource-rich states to source the major part of their revenue from economic rent. Whether Nigeria is seen as a Dutch-diseased or rentier state, the fact remains that its economy basically depends on oil. This hurts the productive sector including agriculture and manufacturing. Sadly, the country's hitherto vibrant agricultural sector has been seriously destroyed by the oil curse.

Nigeria's economy stands to benefit enormously from diversification, and investment in agriculture presents the best prospect compared with other sectors. In spite of the

many daunting challenges, agriculture can engender the much-expected economic emancipation and national transformation. Modern agriculture is more positioned to achieve this feat given the ever-expanding global and domestic markets, the progress made in biotechnology, and the ongoing evolution in information and computer technology. The enormous potential of Nigeria can be attained if the right development policies are formulated and judiciously implemented to rejuvenate agriculture and diversify the economy.

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Black Gold Politics And Sustainable Development In Nigeria

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Abstract: *Nigeria is home to oil and gas, but its accruable revenues have not translated to enormous growth and development in the country. Lack of good leadership to transform these resources to wealth has been a major problem. Consequently, the policies and politics of bad governance have negatively influenced growth and development in the sector. Poor institutional and policy framework and imbalance in oil production and consumption has also contributed immensely to the challenges in the sector. There are also politics of accountability and transparency among the stakeholders in the sector. The government is not left out, as the oil revenues which would have been used for meaningful ventures for national growth are wasted and stashed in foreign banks. It is a general view that the influence of politics has not done any good to the sector. Hopefully, the new Petroleum Industry Act (PIA), if well implemented is capable of righting the wrong and transforming the huge resources to wealth. The players in the sector must exhibit a high sense of responsibility, probity, and integrity. By so doing, the environment would be preserved, the economy would grow, the standard of living would rise, and the country would elevate in the committee of nations as a sustainable developed country.*

Keywords: Crude oil, production, policy, politics, environment, sustainable development

CITATION:

Okon, A. A., Obot, O. W. and Okon, E. A. (2023). Black Gold Politics and Sustainable Development in Nigeria. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp 679-690

INTRODUCTION

Nigeria is blessed with abundant energy resources, especially in oil and gas. Oil deposit was first discovered in Oloibiri in present day Bayelsa State in 1956. Just after the discovery, Nigeria, formerly known for her agrarian system and extraction of other solid minerals abandoned them for oil and gas production. According to Worldometer (*Worldometer, 2022*), Nigeria is currently ranked 10th and 15th in the global oil reserve and production with about 37 billion barrels and 1.9 million barrels/day respectively. Also in natural gas, the country is ranked 9th and 12th in natural gas reserved and production with 186,610 billion cubic feet (bcf) and 3009 bcf/year respectively. However, the huge revenues from the sector do not translate to economic and infrastructural development in the country. With a huge population of young talented professionals, massive arable lands, and vast deposits of other mineral resources, Nigeria ought to be the African giant, but sadly the country is currently ranked one of the poorest in the world with very poor infrastructures and low standard of living, (*NBS, 2022a*). The Nation's greatest problem has

been leadership. Successive governments have failed to transform enormous national resources into wealth, (*Okonjo-Iweala, and Osafo-Kwaako, 2007*). The country's leadership is often based on criteria such as tribe, religion, social and political class, instead of prioritizing merit and track records of individuals seeking positions of leadership. The general opinion is that the national oil production and its accruable revenues are being controlled by some individuals, while the masses live in abject poverty. Politics is said to have eaten deep into the fabric of the country, influencing all sectors of the nation's life including oil and gas. This paper, therefore, attempts to examine the rot in the oil and gas industry, as a result of the influence of politics and its impact on national sustainable development. The study is limited to three key areas of the institutional and policy framework, oil production and consumption and the management of its accruable revenues using available secondary data.

Institutional and Policy Framework

The Nigerian National Petroleum Cooperation NNPC was established about 45 years ago as a sole manager of the Nigerian oil and gas industry. Its subsidiaries coordinate various operations such as oil and gas exploration, production, refining, marketing, corporate governance, and others. Oil and gas operations by international oil companies (IOCs) and indigenous companies in most cases are carried out as joint venture operations with the NNPC and the net revenues go to the Nigerian Government. Over the years, the corporation had come under heavy criticism on its operational efficiencies, transparency, and accountability, as their entire activities remain a top secret to the public, (*Adamu, 2022*). Recently the corporation has transformed into a company known as Nigerian National Petroleum Company limited (NNPCL) incorporated with the Corporate Affairs Commission of Nigeria (*NNPC, 2021*), thanks to the mandate of the newly passed PIA. The new company is expected to formulate a formidable corporate governance framework to eliminate government interference and function fully as a commercial and profit-oriented entity. However, a close look at the composition of the board of directors of the new firm reveals more of political elites (across the six geopolitical zones of the nation), rather than experienced business executives, (*Nathaniel, 2022*). Also, the challenges of issues such as the existing joint ventures of the NNPC with the commercial companies, the usual accruable revenues from the NNPC to the government, and many more have compelled the new NNPCL to continue operating as the old NNPC, a case of the proverbial "new wine in an old wine skin". The NNPCL keeps subsidizing imported petroleum products into the country with controversial figures, a duty completely out of its purview with the current extant laws (*Petroleum Industry Act, 2022*).

On the area of policy framework in the sector, the Nigerian oil and gas industry is not short of legislation to guide its operations, as there are numerous of such laws. These include the environmental Impact assessment act, environmental guidelines, and standards, associated gas reinjection act, oil and gas pipeline regulation, petroleum drilling and product regulation, and flare gas prevention of waste and protection regulations (*IEA, 2022*). The challenges have been the implementation of these laws as they are being violated on daily basis, while the perpetrators go unpunished. For instance, oil spillage is almost a common occurrence in the region and those behind the acts are rarely prosecuted. Where judgment is secured, the private entities fail to abide by the ruling of the court. IOCs are seen as higher entities that cannot be punished locally when their operational standards are compromised. The reasons why the government agencies

saddled with the responsibilities of ensuring that erring operators are sanctioned remain questionable. The general view of many Nigerians is that these companies operate below the set standards in exchange for some form of gratifications to "powers that be".

Oil Production versus Consumption

Nigerian crude oil is a case of oil everywhere but no petroleum products for the citizen to consume. Crude oil production fell from 2.04mb/d in September 2021 to about 1.10mb/d in May 2022, rose to about 1.69mb/d in September 2022 and has remained within this margin presently (*Punch, 2022*). The reduction on the daily production is because of the oil theft prevalent in the region. The estimated oil consumption in the country stands at about 469,000b/d. Table1 compares the quantity of crude oil produced and consumed in five oil producing countries with reference to their population. The population – oil consumption ratio shows that while 1 barrel of oil is consumed by 451 people in Nigeria, 49 and 104 people in Iraq and Algeria respectively consume the same quantity of oil. Also 16 and 15 people in the US and Saudi Arabia respectively consume the same quantity of 1 barrel per day. This information reflects the quality of life and the economic growth in these countries, as a high consumption of oil means high standard of living and enhanced economic growth and productivity.

Table 1: Crude oil production and consumption (million barrels per day among some oil producing countries

Country	Population	National GDP (US$)	Oil Prod. (mb/d)	Oil Consup. (mb/d)	Individuals/barrel
Nigeria	**211400704**	**2085**	**1014000**	**469000**	**451**
Saudi A	35340680	23586	10957000	2375000	15
Iraq	41179351	5048	4651000	833000	49
Algeria	44616626	3765	1060000	429000	104
US	331893745	69288	11971000	21091000	16

Source: Worldometer, (2022).

Many Nigerians queue up daily at petrol stations across the country to buy fuel at a very exorbitant price. Consequently, the cost of transportation, food stuff and other sundry expenses have skyrocketed. Many homes sleep in total darkness at night due to the high cost of fuel for generators. The major cause of this problem has been the importation of the fuel products at international price. Therefore, while the government lavishes the exported oil revenues, the poor masses struggle to buy the products at international rates. At present, the cost of petrol, kerosene, diesel rose from 165, 350 and 560 Naira per liter, respectively in February 2021 to 550, 800 and 1000 Naira per liter in February 2023. The four refineries in Nigeria (two in Port Harcourt, one in Warri and Kaduna), continue to remain dormant in the last few years. The four refineries had a total installed capacity of about 445, 000 barrels per day (Africacheck, 2023), but had been operating over the years at a capacity less than 50%, with billions of naira spent regularly on turn-around maintenance. When it was no more sustainable to maintain them, they were eventually shot down paving way for total importation of the refined petroleum products. It is worthy of note that the recurrent expenditures of those working in these idle refineries are growing steadily in each annual national budget. The

overall impact is that while the oil production and consumption shortages hinder national growth and development, some elements in the industry steadily grow their "illicit" wealth.

The Politics of Oil metering in Nigeria

One of the major challenges in the Nigerian oil sector is the lack of accurate and transparent measurement techniques for the crude oil produced in Nigerian oilfields. The NNPCL has continued to rely on IOCs and local firms for production data (Eboh, 2016). But relying on the production companies for national crude data shows a lack of checks and balances among the players in the sector. This can encourage under-reporting of the actual quantity produced. Despite the available modern digital flow meters capable of measuring and sharing the oil data in real-time, Fig.1, the government agencies saddled with the responsibility seem not to realize the necessity of deploying such instruments in the sector.

Fig. 1: A certified crude oil flow meter. Source: McCrometer, 2021.

Compared to other oil-producing countries like Saudi Arabia, United Arab Emirate, Kuwait, Russia, and the United States of America with state-of-the-art digital metering systems (Dagoumas *et al,* 2018; Arif and Al Senani, 2020), Nigeria continues to use ineffective means of measurement. Between the period of 2012 and 2015, about 107 million barrels of oil were not accounted for due to unreliable metering systems (NEITI, 2015). Also, NEITI in its 2019 annual report said Nigeria loses about 123 billion naira annually owing to ineffective oil metering and urge the players in the sector to come up with a more realistic and effective means of measurement (NEITI, 2019). After many decades of oil discovery, Nigeria, has refused to install good tracking devices to monitor crude oil production and transportation. But who is benefiting from these reported crude oil losses? Why have their identities remained unknown over these years despite the annual auditing by various departments and agencies of government? Why is it so difficult to deploy the modern digitalized and reliable metering system in the sector? These questions would continue to seek answers until the politics inherent in the system is eliminated. Sadly, the country is short of a large proportion of its OPEC oil supply quota. The Nigerian Upstream Petroleum Regulatory Commission, NUPRC, in its December 2022 oil production data, put the total oil production at 1.41 million barrels per day, about 0.40 million short of the 1.8 million barrels OPEC quota for Nigeria (NUPRC, 2022, Vanguard, 2023).

This shortfall results in dwindling national revenues. Consequently, the nation has continued to borrow annually to fund the budget and a large chunk of the annual budget is used in servicing the previous loans in place of the capital projects. A nation that embarks on minimal capital projects is likely to face an infrastructural deficit that hinders sustainable development. No wonder the country is faced with a myriad of infrastructural collapses from power, transportation, housing, communication, and others with the attendant weak economy, high cost of living, and unrest in various parts of the country.

Oil Theft, an Organized Crime by Cartels

Oil theft has become a cash cow in the Niger Delta region of the country. NNPC in a press briefing (Premium Times, 2022) disclosed their discovery of an illegal connection from the Forcados terminal that has been siphoning oil from the line in the last nine years. Sources (Addeh,2022; NNPC, 2022) also claimed that Nigeria lost about 4.3 trillion worth of oil between January and July 2022. Most of the reported cases of stolen oil are tapped from the oil transmission lines from production to storage facilities, Fig. 2. Many groups are said to be involved in this crime, including militant groups, some members of the security agencies and some workers of the oil operating companies in the region.

Fig. 2: A tapping of a major crude oil pipe by oil thieves. Source: (SUN, 2022).

Workers of the oil exploration companies are fingered in this deal, as the highly specialized skills exhibited in tapping the oil from the trunk lines could not have been carried out by novice artisans. Security agencies are not left out in this mess, as those drafted to safeguard the oil facilities are said to be involved in the crime (Guardian, 2022). One then wonders how these oil thieves get away with the stolen crude under the watchful eyes of the heavily armed security operatives if there were no acts of connivance.

The leadership of these security agencies does not equally help matters as they are usually seen to be silent or reluctant to apprehend, investigate and punish erring personnel. Tired by the incessant cases of oil theft and the inability of the government to meet the OPEC quota for the nation's crude export, the Federal Government of Nigeria in 2022 contracted the oil pipe surveillance to a vigilante group (Tantita Company Limited), led by an alleged former militant leader in the Niger Delta region (Guardian, 2022; BusinessDay, 2022). Barely a few months after the contract award, the number of stolen oil sites discovered, and the number of vessels ladened with illegal crude seized is mind-blowing (Vanguard, 2022; Shipping Position, 2023). In one of the seizures, the boat filled with a large quantity of crude oil was set ablaze by the security operatives who accompanied the vigilante company (Leadership, 2022).

This action by the security personnel was seen by many as a cover-up of those behind the crime. While a major portion of the stolen oil is sold to foreign mercenaries for onward export to other countries, others are refined via artisanal means and sold as refined products in the local

"black" market. The politics that seem to have played out in these scenarios are that, over the years oil theft has been a highly organized deal by many groups, including those saddled with the responsibilities to prevent the crime. These actions have grave consequences on the economy, environment, and social fabric of the nation. The stolen oil deprives the government of the revenue needed to support key sectors of the economy such as health, education, housing, etc., which are in dire need of huge financial bail-out. By extension, monetary values are negatively affected, and this trickles down to high prices of local goods in the country, as experienced today. These acts are also challenging to the operating companies, as the stolen oil negatively affects their productivity and profitability.

Consequently, many IOCs have either downsized their operations or sold out their facilities to indigenous firms (Daily Trust, 2022; Seplat Energy, 2022). Some of the stolen oil vessels had been seized in foreign climes, thereby sending negative signals to the investors about the integrity of the handlers of the oil sector in the Country. These crude, unprofessional, sharp practices scare away foreign direct investors when the nation needs these investments in the current energy transition era. In some cases, some of the stolen crude is spilled and where no one claims responsibility, the cleanup is hardly carried out. Therefore, the oil destroys the farmlands, pollute the water, and render the inhabitant jobless.

Oil Spillage: A Free for all Players

An oil spill is a common occurrence in the Niger Delta region of Nigeria. Huge barrels are spilled on land and in water during production and transportation from the facilities to the storage terminals. Causes of the oil spill in the region range from faulty facilities, negligence by the operating companies, and sabotage by oil thieves, (Mbaeltal, 2019). Table 1 shows the incidences of the oil spill by the major oil operating companies in the country between the period of January 2010 and December 2022. The table indicates that about 11,178 incidences of oil spill had occurred with a total quantity of spillage put at about 479,682 barrels (NOSDRA, 2022a), exclusive of those from the smaller operating companies.

NAOC, an exploration and production company with over 60 years of operational experience in Nigeria had about 5,185 incidences of the oil spill for a total of 104,505 barrels within the period under review. Also, SPDC had 2,799 incidences and 180.947 barrels of spillage, while others like Chevron, PPMC, and others had their fair share too. It is generally believed that these companies with long years of technical and operational experience could not have spilled this humongous quantity of oil without any sense of carelessness and negligence. Aiteo Eastern exploration Company in November 2022 had a major oil leak in one of its facilities in Nembe, Bayelsa State (fig.3) and the high-pressure spillage lasted for about one month without stoppage (Vanguard, 2021; BusinessDay,2021). By NOSDRA standards, any spillage should be caped within 24 hours, but this incidence lasted for over four weeks contaminating the entire communities in the area. This huge amount of oil spill contributes to the severe pollution already suffered by the inhabitants of the communities in the Niger Delta. What of the wastage of the spilled oil? Who pays for it? at a time when the country is unable to meet its OPEC production quota with a wobbling national economy. The truth is that there are no serious penalties for oil spillage in Nigeria.

The authorities have refused to enact laws with stiffer penalties like revocation of the operating license of the firm involved and prosecution of those that are directly linked to

the spillage, to serve as a deterrent to others. According to NOSDRA (*NOSDRA,2022b*), there is no legally binding regulatory penalties or fines for the oil spill in Nigeria. Instead, the operating companies are required to clean up the spilled oil and pay compensation to the host communities if the faults were theirs.

Table 2: Oil spill data from production and exploration companies.

Company	Incident	Barrels
ADDAX	44	2212
Aiteo E& P	35	17842
CHEVRON	499	3967
ENAGEED RESOURCES LIMITED	52	362
ESSO	23	100
EROTON E&P	150	24318
FIRST	42	589
HERITAGE	195	17976
MPN	708	44121
MIDWESTERN	30	254
NAOC	5185	104505
NDPR	14	207
ND WEST	41	5663
NPDC	307	49238
NECONDE	15	393
POOCN	24	111
PPMC	689	18567
PLATFORM	20	45
SEEPCO	17	1994
SEPLAT	162	1545
SPDC	2799	180947
TOTAL	127	4726
Total Incidents and quantity	**11178**	**479682**

Source: (*NOSDRA, 2022a****).***

The truth remains that the government agencies saddled with the responsibilities of check-mating these earing entities have neglected their responsibilities of ensuring that these companies adhere strictly to the operational and safety standards. Oil spill in the region is sometimes viewed as a case of being rather cheaper for the operating companies to neglect their operational standards and financially induce the "powers that be" in case of any eventuality. When this spill occurs, the environment suffers degradation, the inhabitants of the areas lose their sources of livelihood, the unscrupulous individuals enjoy gratifications, and the operating companies ensure their profit margins.

Oil Revenues, a Goldmine for the Leaders.

As Nigerian refineries are currently not functioning optimally, almost all the crude oil produced in Nigerian is exported to other countries of the world. Before now, crude oil sales had been the main contributor to the national revenue. There has been a steady reduction in the oil contribution to the national revenue due to the outrageous expenses of the subsidy on the imported premium motor spirit (PMS) to the country. The oil revenue is shared among the three tiers of Government for their recurrent and capital expenditures. Let us now examine these oil expenses in detail.

Rising Fuel Subsidy and Shrinking Oil Revenues.

One of the key questions seeking answers in the Nation is the quantity of PMS imported into the country and the actual amount paid by the government to subsidize the product. In April 2022, the NNPC based the total fuel imported into the country on the quantity of fuel consumed daily which was put in the range of 60 to 100 million liters per day. This claim has been the subject of controversy among stakeholders including government agencies. In a press interview in March, the Minister of State for Petroleum Resources described the fuel subsidy regime as "a criminal enterprise", stating that the regime had created room for criminal tendencies like smuggling and diversion of subsidized petroleum products to other neighboring countries.

*Fig. 3: An Aiteo Eastern Exploration and production Company Limited OML-29 Well 1 oil spill site in Nembe, Nigeria, (*Vanguard, 2021).

He lamented how the exact quantity consumed was unknown both to the petroleum ministry and the national oil company. These uncertainties have led to the arbitrary fixing of the cost of fuel subsidies annually by the government. Figure 4 shows the variations in the amount of money spent on fuel subsidies between the period of 2019 to 2023 (projected). The analysis indicates that fuel subsidy increased by 1.22 trillion in 2020, decreased by 0.14 trillion in 2021, and increased substantially in 2022 and 2023 (projected) by 2.91 and 2.61 trillion respectively. Overall, the cost of fuel subsidy increased from 0.35 trillion in 2019 to 7 trillion in 2023 amid oil price booms.

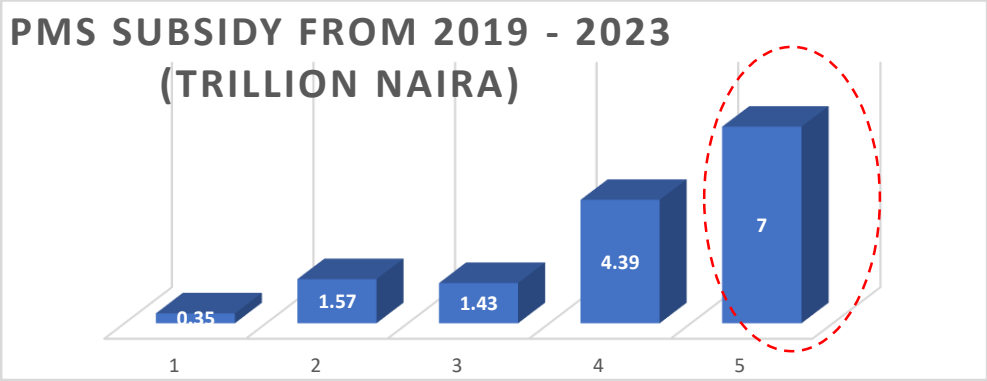
Figure 5 also shows the percentage contribution of the oil revenues to the national budget. The analysis indicates a steady decrease in the amount of money accruable to the budget from the oil sector. The contribution fell from 53% in 2019 to 21% in the 2023 projected budget. These reductions are invariably attributed to the ever-rising fuel subsidy cost shown in fig. 4. While many oil-producing countries of the world are leveraging on the current oil boom due to the Russian- Ukraine hostility, the global rise in oil prices seem to be a liability to the Nigerian Government.

Cases of submission of claims by various interest groups for payment of imported petrol that was never brought into the country abound. It is a general believe that the subsidized fuel importation regime has been overtaken by cartels whose aim is to simply loot the national treasury at the expense of the poor masses suffering under very harsh economic conditions. Sadly, it seems that there is no basis for fixing the cost of fuel subsidy in each year's budget and there are usually doubts about the huge amount of money spent annually on the subsidy. Lack of transparency and accountability make it obvious that the fuel subsidy regime has become a cheap means of looting the national wealth as the whole process is shrouded in secrecy. Fuel subsidy has consumed so much money that would have been used to build the national economy. The amount spent on fuel subsidies annually is far more than the sum of money allocated to three key ministries (Education, Health, and housing) (Budget office, 2022). The 2023 budget stands at about 21.8 trillion, with 11 trillion expected revenues, and a deficit of about 10.8 trillion, while a whopping 7 trillion naira have been earmarked for fuel subsidy. Invariably fuel subsidy has contributed substantially to the annual borrowing of the federal government to fund the budget. Indeed,

the oil sector in Nigeria is being controlled by "unknown forces" other than the usual demand and supply.

Reckless Spending of the Oil Revenue

Nigeria relies on oil revenues and taxes with little or no other income from non-oil resources. On monthly basis, these revenues are shared among the Federal Government, the 36 States (including Abuja), and the 774 Local Government Areas of the Country. Table 3 shows the amount of money shared by these tiers of Government in four Federation Allocation and Account Committee (FAAC) meetings in 2021 and 2022.



. ***Fia. 4:*** *Annual cost of fuel subsidv. Source:* Budget office, 2023

Table 3: The Federal Account Allocation Committee (FACC) financial allocations to the three tiers of government (Amount in Billion) (Source: National Bureau of Statistics (NBS, 2022b)).

Month/Year	Federal Govt.(Billion)	State Govt.(Billion)	L.G.As (Billion)
December, 2021	279.46	221.19	163.88
March,2022	236.18	190.01	140.61
June, 2022	321.86	245.42	182.33
August, 2022	406.16	281.34	210.62

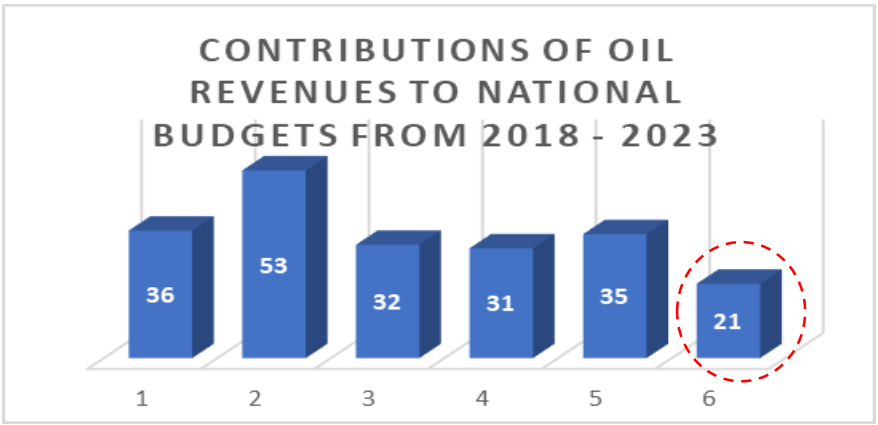


Fig. 5: *Contributions of oil revenue to National budgets. Source:* Budget office, 2023.

These huge amounts are shared between the federal government, the 36 states, and the 774 local government areas for the sole purpose of running their recurrent and capital expenditures. However, some of these funds go for the chattering or outright purchase of private jets for the local and foreign travels of government officials. Humongous salaries and allowances are paid to political office holders and other related interests. Some government officials move in convoys with several luxury cars. Security votes are among the first-line charge withdrawn from the State treasury. Huge pensions and gratuities are paid to political office holders with limited tenures in office (Onyekwere, 2019). On the capital expenditure side, projects with no direct bearing or immediate needs of the people are embarked with over-inflated contract sums. In all these, the oil revenues are embezzled and development in such areas is dashed while the masses wallow in poverty.

Impact of Oil Politics on Nigeria's Sustainable Development

Weak institutional frameworks breed weak and conflicting policies with challenging legal and accountability issues in the Nigerian oil sector (Ramon, 2022). This hinders the smooth running of the sector and reduces the investors' confidence in committing substantial funds to the sector. This reduces growth and sustainable development in the sector and the nation at large. Fortunately, the PIA, has come to streamline all the anomalies in the sector. The imbalance between crude production and consumption causes havoc in the country. Relying on foreign importation of refined petroleum products into the country at an international price remains a serious problem in the country. The annual cost of fuel subsidy is almost equivalent to the national budget. Characterized by high prices, scarcity of products, and panic buying, Nigerians nowadays spend days queuing in petrol stations to buy the products. These raise the daily cost of living of Nigerians to an all-time high.

Poor oil metering and oil theft have a common denominator, the huge amount of oil that would have been sold to enhance the nation's foreign earnings and national revenues is lost. Low revenues mean poor development, as the government finds it difficult to fund capital-intensive projects that would have turned around the national fortunes. Less foreign earnings and revenues have a negative impact on the country's external reserve, currency exchange rate, and other economic indices with the attendant high cost of living. Nigeria is now faced with a high unemployment rate, as many companies have moved to other countries with the favorable business environment. Poor economic outcomes like these hinder the sustainable development of any country. Oil spillage, apart from the loss of oil with attendant consequences earlier enumerated, degrades the environment. Environmental pollution in this case includes air, land, and water. Air pollution enhances climate change, polluted arable lands are rendered useless and polluted water kills aquatic life and destroys the entire ecosystem. When the environment is destroyed and members of the host communities are unable to feed themselves, thereby leading to social unrest, sustainable development is greatly dampened. A nation that does not manage its resources judiciously runs into borrowing perpetually. No wonder Nigeria has borrowed so much from local and international lenders. Sadly, some of these loans are used for recurrent expenditures and servicing of previous loans, without investing in capital projects that can repay the loans. A cash crunch for a nation weakens all its economic indices and truncates its sustainable development.

Conclusion

The politics of oil policy, production and consumption, and management of accruable revenues have had a negative impact on the nation's fabric, as the nation depends greatly on oil. These have resulted in poor economic indices with the overall effect of negative growth and development. However, there are hopes of economic resurrection with the new PIA, where oil and gas policies are well streamlined, and responsibilities specified. The necessary measures must be put in place for proper checks and balances between the different government agencies and other stakeholders. The war against oil theft must be sustained. The operating standards that reflect the global best practices must be followed by all stakeholders. The sector should be fully deregulated for it to be influenced solely by demand and supply forces. More transparency should be enthroned in managing the revenues accruing from oil. Such funds should be channeled to meaningful projects that can transform the economy of the nation. Modular refineries to refine crude oil for local consumption should be the most priority at this time to reduce or eliminate the importation of refined petroleum products and removethe sabotage by handlers of the fuel importation.

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Cassava Yield Forecasting Using Artificial Neural Network

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ABSTRACT: *Many people in Nigeria and other countries of the world depend on cassava products as their major source of food. Forecasting the yield of cassava makes farmers and agricultural stakeholders proactive in strategic planning towards its availability for the teaming population. The complexities of Cassava Yield Forecasting (CYF) incapacitate linear models in producing accurate results. Sequel to the necessity of comprehending the patterns, influence and parameter combination for optimal cassava yield forecasting, this work proposes Artificial Neural Network (ANN) paradigm with abilities to learn from previous yield parameters and generalize into unseen patterns. ANN model for CYF was designed and furnished with hyperbolic transfer function in the hidden layers while Sigmoid transfer function was deployed in the output layer. The cassava dataset with 2500 samples was collected and used for training and testing of the model. Least training and testing errors of 0.0013 and 0.0259 respectively were observed in the ANN model. Investigations regarding cassava yield based on the number of cassava cultivars planted per stand revealed that the cultivation of one stem per stand had a higher contributory effect on average cassava yield than cultivation of more stems per stand. The ANN model earned 94.80% and 96.10% for accuracy and precision metrics respectively, indicating acceptable performance. Detailed ANN investigations of cassava yield patterns in response to cassava varieties, soil types, fertilizer types, weather conditions and cultural practices as well as intelligent computational techniques for selection of ANN optimal training parameters are recommended for further research with a view to improving cassava yield forecasting.*

Keywords: cassava yield forecasting, artificial neural network, agriculture

CITATION:

Udoh, S. S., George, U. D. and Etuk, U. R. (2023). Cassava Yield Forecasting Using Artificial Neural Network. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Professor Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 667-679

Introduction

A significant percentage of global cassava production is contributed by Nigeria. However, the production potential has not been harnessed for significant economic growth in the country (Fondong, 2017). Timely and accurate forecasting of cassava yield is of great importance in strengthening global food security. Although forecasting is a complex and challenging task, machine learning approaches have recently shown predictive prominence (Udoh *et al*., 2017; Nevavuori *et al*., 2019; Khaki *et al*., 2020). Alison *et al*., (2019) presented cassava root yield prediction using the linear regression modelling approach. Prediction accuracy was only based on correlation coefficient. The model lacked the ability to learn cassava yield patterns from previous data.

Ikuemonisan and Akinbola (2021) deployed statistical tools to forecast cassava production using indicators in Nigeria. Findings showed that 84% of total cassava output was projected to be available for consumption and that 29% of the 84% was lost during post-harvest activities. The accuracy of the model was not evaluated in addition to non-inclusion of learning modules to

guide intelligent decisions. Sadenovaa *et al.,* (2021) used mathematical model to predict crop yield. Dynamic characteristics of predictors were studied to predict productivity with correlation coefficient (CC) as the metric of choice. The CC between the calculated yield values and the official statistics was 0.84.

Artificial neural network (ANN) paradigm evolves from the simulation of learning mechanisms in biological organisms (Aggarwal, 2018). ANN is more attractive than conventional learning methods primarily when sufficient data and computational power is available. ANN has strengths of learning from previous data, memorizing salient features, recalling data patterns and generalizing into future outcomes using unknown examples (Udoh and Olabode, 2010; Rout and Bagal, 2017; Udoh *et al*., 2019). This work adopts ANN methodology for CYF with capabilities to decipher the hidden and non-linear relationships among cassava yield parameters to activate accurate forecasting and decision processes. This work would provide a guide to agronomic strategic planning towards forecasting the yield of cassava in the agricultural sector, provision of food as well as income for economic sustenance.

Related works

Reinhard (2010) experimented on agronomic practices for sustainable production of cassava. The work showed that cassava yield is negatively affected when either rainfall or temperature is low in the first 3-5 months after planting. It was shown that planting in ridges is better in the rainy season whereas planting on flat surface is better in the dry season. Consideration of varieties of cassava cultivars, soil types, variation in soil properties and differences in atmospheric conditions could be incorporated to substantiate the experiment. Odubanjo *et al*., (2011) investigated the effect of different amounts of supplemental drip irrigation on the tuber yield of cassava and showed that the soil with 100% drip irrigation produced 600% cassava root yield compared to the soil with no irrigation.

A spatial model to assess the suitability of land for supporting sustainable cassava production was reported in Purnamasari *et al*., (2019). It was shown that cassava grow very well in the tropics, between 30°N and 30°S in areas where annual rainfall is greater than 500 mm and mean temperature is greater than 20 °C. Ezedinma *et al*., (2007) presented the opportunities and challenges for production of cassava in Nigeria. Lack of exploitation of the potentials of cassava production in contributing to economic growth motivated the work. Amanda *et al*., (2017) examined physiological processes underlying productivity in cassava and provided some strategies for yield improvement through genetic alterations. The study revealed that although informed use of fertilizer could lead to increase in yield, the genetic yield potential of cassava sets the ceiling on what may be produced at a given location, Tunrayo *et al*., (2017) developed site-specific recommendations for cassava production in Nigeria and Tanzania. Geospatial information obtained were related to climate, soil and remote sensing data. Spatial multivariate analysis was used to delineate agricultural extension partners' operational area into homogeneous clusters. Multivariate cluster analysis provided unbiased guide for site selection for technological innovations.

Many researchers have deployed various methods in the task of CYF. Oni and Akanle (2018) forecasted cassava production using moving average, trend analysis and smoothing models. The work compared exponential smoothing models and inferred that cassava production in Nigeria is not affected by season. Time forecasting was very practical and accurate compared to other models. The study showed that the simple exponential smoothing model is better in forecasting the yield of cassava

compared to Winter's additive, Winter's multiplicative and Holts' trend models. Alison *et al*., (2019) presented cassava root yield prediction in different water regimes. An agronomic and physiological data of final root yield obtained under two water regimes were tested using four prediction models: linear regression with backward selection, linear regression with stepwise selection, partial least square and Bayesian ridge regression. There were differences in the predictive ability of the models due to early traits of the crop regardless of the water condition. Klompenburg *et al.,* (2020) investigated the best time for cassava planting to achieve maximum yield. A growth simulation model for cassava called SIMulation of CASsava (SIMCAS) was trained to predict cassava growth yield. It was observed that the predicted and observed values were reasonably close. SIMCAS was considered a good model that could predict correct planting time and potential yield of cassava at a given location.

Al *et al*., (2020) presented breeding and agronomic research on cassava production. The breeding programme successfully realized high-yielding cultivars with significant economic benefits. Building resistance to invasive pests and diseases have become a top priority due to the emergent threat of cassava mosaic disease. Further exploration in data-driven agriculture is needed to guide researchers and farmers towards sustainable navigation in innovative technology. It is reported in Frooq and Pisante, (2019), that cassava yield (CY) depends on various factors such as water, soil type, soil nutrients, climate and the environmental factors. However, experiments could be carried out to substantiate the relationship and the nature of correlation between CY and the aforementioned variables. Kintché *et al*., (2020) studied CY loss in two provinces of the Democratic Republic of Congo. Boundary line approach was used to investigate the CY loss. Forty-two cassava farms in Kongo central and thirty-seven farms in Tshopo were analyzed to find out how soil fertility, farmers' cultivation practices as well as pest and disease infestation affected CY. Logistic regression modelling revealed that pests and diseases played a sparse role in the yield losses. Low soil fertility led to decrease in cassava yield in many farms.

Moreno-Cadena *et al*., (2021) reviewed the growth and yield of cassava crops. The goal was to study Eighteen published cassava models and gain more insights on their capability to simulate storage root biomass and to categorize them into dynamic and static models. Fourteen models were dynamic while four models were static. The dynamic models simulated the growth process and provided the yield estimates but lacked ability to predict maturity date and were less-accurate in simulating the detailed development of nodal units as well as determining the final yield. The four static models were useful in estimating cassava yield. However, the models were evaluated using a limited range of predictors thereby hindering comprehensive assessment of non-linear relationships between input variables and CY.

Nevavuori *et al*., (2019) deployed convolutional neural networks (CNNs) for CY forecasting. The CNN methodology tested the selection of the training algorithm, network depth, hyper parameters on the regularization strategy and the prediction efficiency. Khaki *et al*., (2020) compared CNN, fully connected neural networks (FNN) and random forest (RF) in the task of crop yield prediction. It was reported that CNN model outperformed other tested models in CY forecasting. It captured time dependent environmental factors, generalized the yield prediction to environments that were not part of the test and revealed the extent to which weather conditions could affect CY.

Summary of weaknesses of the works reported in Frooq and Pisante (2019), Khaki *et al*., (2020), Ikuemonisan and Akinbola (2021) and

Sadenovaa *et al.,* (2021), are: deployment of linear models with lack of ability to decipher non-linear patterns in data. Deployment of few prediction variables which hinder proper investigation of non-linear interaction. Deployment of small data set and few evaluation metrics which impede overall test of accuracy, efficiency and reliability of the model. The current research deploys ANN model to deal with complexities and non-linear patterns in CY forecasting. Large data set with fourteen prediction variables are incorporated to investigate hidden patterns and non-linear interaction in the prediction process. Decision metrics are deployed to evaluate the accuracy, recall, specificity and precision of the ANN based CYF model.

Materials and methods

The operational procedures for CYF comprises four main stages namely: Agronomic data set, pre-processing, ANN modelling and model evaluation. The agronomic dataset holds agro-climatic variables, location-based factors, farmers' parameters and other Cassava production-related data. Pre-processing task includes feature scaling, encoding of categorical variables as well as identification of relevant features for CYF. At this stage, the extraction of variables that influence cassava yield was performed and the data set was split into three groups for training, testing and validation operations. ANN modelling was performed using NeuroSolutions 7.0 software tools and the result was evaluated using performance assessment metrics such as accuracy, specificity, recall and precision. The model with least training and testing errors earns the approval for deployment in forecasting of cassava yield. Details of the methods involved in the modelling are described in the following sections.

Cassava yield data collection

Data totaling 2500 samples were collected over a period of one year (March, 2021 to March 2022) from Akwa Ibom North-West Agricultural zone, southern Nigeria. The study area covered forty (40) cassava farms, comprising four (4) farms from each of the ten (10) Local Government Area making up the Agricultural zone. Twenty (20) of the forty (40) farms were planted on flat surface while the other 20 were cultivated on ridges. Each of the 40 farms was divided into five (5) plots. Each of the plots was used in cultivating a particular variety of cassava. The cassava stem was cut 30 cm long and planted with 1 m x 1 m intra and inter-row spacing. There were six (6) rows with ten (10) plants per row, making it sixty (60) plants per plot. Ikot Ekpene, the main study area is located at Latitude 5.183^{o}N and Longitude 7.715^{o}E with Elevation of 75.68 2m. Udosen (2012) reported that the average annual rainfall in the main study area is 2007.49 mm with concentration in the rainfall occurring between April and October. The study area has an average day temperature of 32.12 ^{o}C and average night temperature of 23.67 ^{o}C. It has a gentle undulating land with diversity in soil nutrients for cassava production. Cassava yield input/output variables are described in Table1.

Cassava yield forecasting model

The ANN framework for CY forecasting comprises input layer, hidden layers and output layer. The input layer accepts values of variables such as Rainfall/Irrigation (RFI), Temperature (TMP), Number of Stems Cultivated (NSC), Fertilizer Application (FZA), Manure Application (MNA), Number of Stands at Harvest (NSH), Soil Type (STP), Crop Variety (CVT), Pest Control (PTC), Disease Control (DSC), Weed Control (WDC), Crop Duration (CRD), Planting Method (PLM), Unforeseen Event (UFE), that influence the yield of cassava and other crops.

Table 1: Description of Cassava yield input/output variables

SN	Variable	Code	Data Type / Size	Remarks
1	Rainfall/ Irrigation	RFI	Float (6)	RFI was measured in millimetres per day. Average monthly RFI in the study area was computed as 2007.49 mm/day
2	Temperature	TMP	Float (4)	TMP was measured in degree celsius. Average monthly day and night TMP in the study area was evaluated as 27.90 ^{0}C
3	Number of Stems Cultivated	NSC	Integer (1)	NSC value of 1 or 2 or 3 was assigned as input to the ANN Model based on the number of cassava stems (cultivars) planted per stand.
4	Fertilizer Application	FZA	Binary (1)	FZA value of 1 was assigned if fertilizer was applied and 0 otherwise.
5	Manure Application	MNA	Integer (1)	MNA had the values such as: Farmyard MNA(3), Compost MNA(2) and Green MNA(1)
6	Number of Stands at Harvest	NSH	Integer(4)	Values of 60, 50, 40 and so on were assigned to NSH depending on the number of stands of cassava per plot as at the time of harvest.
7	Soil Type	STP	Integer (1)	STP values of 1, 2, 3, 4 were assigned to Sandy, Clay, Silt and Loamy soils respectively
8	Crop Variety	CVT	Integer(1)	Values of 1, 2, 3, 4, 5 were assigned to Poundable, Hope, Game-changer, Baba-70 and Obasanjo-2 cassava varieties respectively.
9	Pest Control	PTC	Integer(1)	Value of 1 or 2 was assigned to traditional or pesticide operations.
10	Disease Control	DSC	Binary (1)	DSC value of 1 was assigned if diseases was controlled and 0 otherwise.
11	Weed Control	WDC	Integer (1)	Value of 1 or 2 was assigned to traditional or herbicide operations respectively.
12	Crop Duration	CRD	Integer (2)	Values of 6, 8, 12 were assigned to CRD based on the duration of crop from planting time to harvesting time.
13	Planting Method	PLM	Integer (1)	PLM had value of 1 for crops planted on flat surface and 2 for those planted on ridges.
14	Unforeseen Event	UFE	Integer (2)	UFE could take values between (-1,1), The values could be negative depending on factors such as total lock-down, terrorist attacks on farmers, massive death of farmers and so on. It could also be positive based on Government incentives to farmers, favourable policies on agricultural production and so on.
15	Crop Yield	CY	Float (6)	CY measured in tones/hectare, served as the output of the system.

The value of each node in the first hidden layer is the sum of products of inputs that influences CY and their respective weights. The value of each hidden layer node generates the output for that node via the activation function while the output of the first hidden layer becomes the input to the second hidden layer and so on. The process continues till the final hidden layer sends its results as input to the output layer which computes its output (CYF value) via output layer activation function. In the ANN schema of Fig. 1, the layers are represented as follows:

i. CY input (variable) layer x_i: $i = 1,2,..., n$

ii. CY hidden (processing) layer h_j: $j = 1,2,..., m$

iii. CY output (prediction) layer o_k: $k = 1,2,...,l$

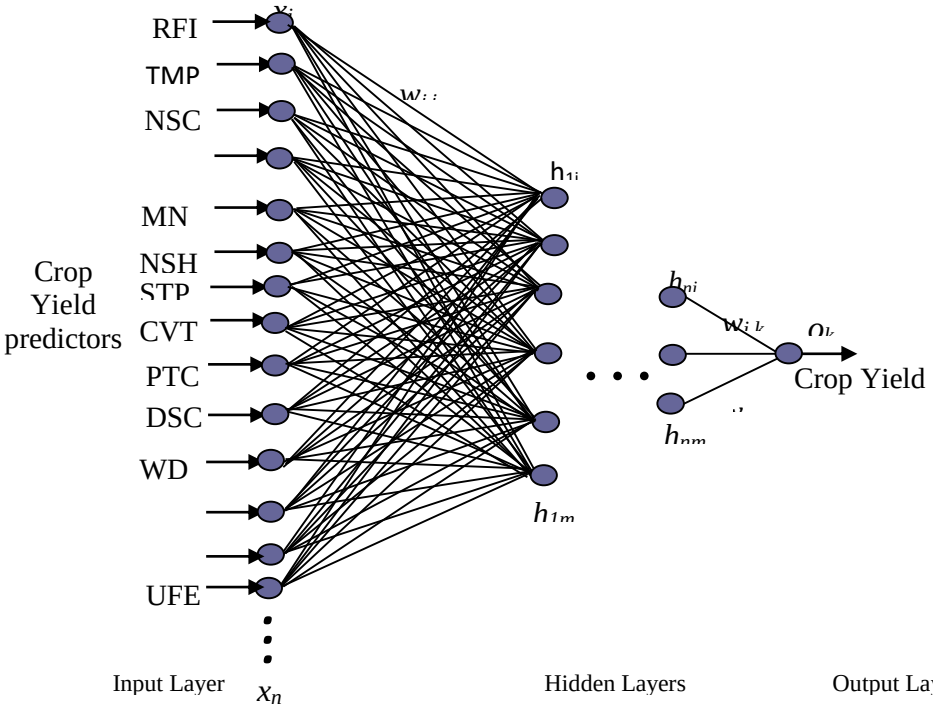


Fig. 1: ANN Schema for CYF

A system of equations is formulated for the input and hidden layers in Eq. (1) and compressed in Eq. (2), where $W_{i,j}$ represents the matrix of weights on the connection from the *ith* node in the input layer to the *jth* node in the hidden layer. *W* is the matrix of weights, x_i is the crop yield input vector and h^* is the hidden layer pre-output. The actual output of hidden layer node h_j is obtained by subjecting the pre-output in Eq. (3) to the hyperbolic transfer function as shown in Eq. (4). Similarly, the computation in the output layer node is performed. $W_{j,k}$ is a matrix of weights that connects *jth* node in the hidden layer to the *kth*-output layer. The output layer equation is formulated as shown in Eq. (5), it is composed in vector form Eq. (6) and compressed as shown in Eq. (7)

The actual value of the output layer node (o_k), is obtained by subjecting the pre-output in Eq. (7) to the sigmoid transfer function as shown in Eq. (8). The final output (o_k), represents the value of crop (cassava) yield forecasting. If the difference (error) between the computed output (o_k) and the desired output (d_k) is greater than a predefined value. The error value is deployed to adjust the connecting weights of output and hidden layers as seen in Eq. (12) and Eq. (13) respectively.

$$\begin{aligned} w_{1,1}x_1 &+ w_{1,2}x_2 + \cdots + w_{1,n}x_n = h_1^* \\ w_{2,1}x_1 &+ w_{2,2}x_2 + \cdots + w_{2,n}x_n = h_2^* \\ &\vdots \\ w_{m,1}x_1 &+ w_{m,2}x_2 + \cdots + w_{m,n}x_n = h_m^* \end{aligned} \quad (1)$$

$$\underset{h^*}{} \quad \underset{W}{} \quad \underset{\chi}{}$$

$$\begin{bmatrix} w_{1,1} & w_{1,2} & \cdots & w_{1,n} \\ w_{2,1} & w_{2,2} & \cdots & w_{2,n} \\ & & \vdots & \\ w_{m,1} & w_{m,2} & \cdots & w_{m,n} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{bmatrix} = \begin{bmatrix} h_1^* \\ h_2^* \\ \vdots \\ h_m^* \end{bmatrix} \quad (2)$$

$$h_j^* = \sum_{j=1}^{m}\sum_{i=1}^{n} W_{i,j}x_i \quad (3)$$

$$h_j = \frac{e^{h_j^*} - e^{-(h_j^*)}}{e^{h_j^*} + e^{-(h_j^*)}} \quad (4)$$

$$w_{1,1}h_1 + w_{1,2}h_2 + \cdots + w_{1,m}h_m = o_k^* \quad (5)$$

$$\begin{bmatrix} w_{1,1} & w_{1,2} & \cdots & w_{1,m} \end{bmatrix} \begin{bmatrix} h_1 \\ h_2 \\ \vdots \\ h_m \end{bmatrix} = o_k^* \quad (6)$$

$$o_k^* = \sum_{k=1}^{p}\sum_{j=1}^{m} w_{j,k}h_j \quad (7)$$

$$o_k = \frac{1}{1 + e^{-(o_k^*)}} \quad (8)$$

$$e_k = d_k - o_k \quad (9)$$

$$\text{SSE} = \sum_{k=1}^{p} (e_k)^2 \quad (10)$$

$$e_j = h_j\left(1 - h_j\left(\sum_{j=1}^{m} w_{kj}e_k\right)\right) \quad (11)$$

$$w_{kj}(n+1) = w_{kj}(n) + \beta e_k h_j \quad (12)$$

$$w_{ji}(n+1) = w_{ji}(n) + \beta e_j x_i \quad (13)$$

$$P(x_i, w_{ji}, w_{kj}, o_k) = \begin{cases} High\ (H) & , \ o_k > \theta \\ Moderate\ (M), & o_k = \theta \\ Low\ (L) & , \ o_k < \theta \end{cases} \quad (14)$$

The process is repeated until the value of sum of squared error (SSE) in Eq. (10) is within a prescribed threshold. Subsequently, the yield predictors (x_i), adjusted hidden layers weights (w_{ji}) in Eq. (13) adjusted output layer weights (w_{kj}) in Eq. (12), ANN computed output (o_k) in Eq. (8) and the crop yield threshold value (θ) obtained from agriculturist are deployed for crop yield forecasting in Eq. (14).

Results and discussion

ANN model for CYF was designed as depicted in Fig.1. Data attributes together with their contributory influence to CYF were deployed in the model as shown in Fig.2. The model was implemented using neural network multilayer perceptron paradigm provided by NeuroSolutions version 7.0 as depicted in Fig. 3(a-d). The model had fourteen input data variables and one output data variable as described in serial numbers 1-14 and 15 respectively in Table 1. In the hidden layers, varying numbers of nodes (between three and six) were deployed for the processing and modelling of CY parameters, while at the output layer, one node was deployed for CYF. The data totaling 2500 samples were split into training, testing and validation data sets in the ratio of 8:1:1. This translated to 2000, 250 and 250 data samples respectively. The model was trained using back-propagation algorithm. Hyperbolic transfer function was deployed in the hidden layers while Sigmoid transfer function was used in the output layer. In Fig. 3d. values of 0.0013, 0.0145 and 0.9424 were observed for training mean squared error (MSE), normalized mean squared error (NMSE) and correlation coefficient while values of 0.0259, 0.2415 and 0.9363 were observed for validation mean squared error (MSE), normalized mean squared error (NMSE) and correlation coefficient respectively. The results showed a satisfactory ANN process and a better performance compared to 0.84 correlation coefficient of the mathematical model reported in Sadenovaa *et al.,* (2021) as well as the 84 % accuracy of statistical model reported in Ikuemonisan and Akinbola (2021),

In cassava yield predictor's scale depicted in Fig. 2. FZA had the highest contribution to CY, followed by NSH and STP. The contribution of RFI, WDC and CRD were almost at the same level. MNA took the seventh position followed by CVT, DSC, TMP, PTC, UFE, PLM and NSC. Although FZA was observed as the major contributing factor to

the yield of cassava. It was observed that other factors such as UFE, PLM and NSC which occupied the last three positions could cause major deviations in crop yield forecasting. For instance, in year 2019 to 2020 there was an unforeseen event (UFE) which seriously affected crop yield. The total lockdown due to corona virus pandemic in the world hindered farming activities which resulted in low CY.

In the agricultural zone in which the study area belongs, there are contentions among farmers on number of stems cultivated (NSC) per stand and planting method (PLM). Many farmers opined that they have high yield from planting two (2) or three (3) stems of cultivar per stand, only few farmers subscribe to planting of one (1) stem per stand. Some farmers orated that they have high yield from planting on ridges while others maintained that they have high yield from planting on flat surface. Hence, there is need to consider the aforementioned predictors in CYF, despite their low grades in predictor's scale of importance.

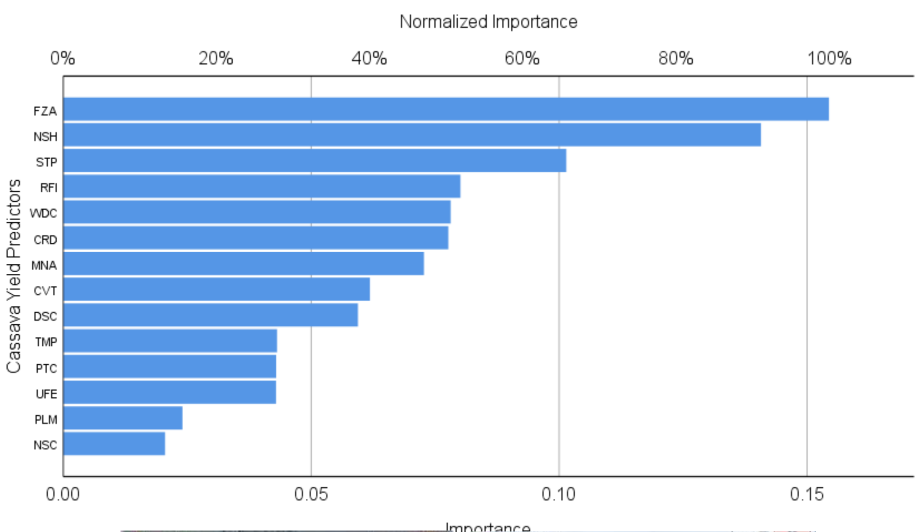


Fig.

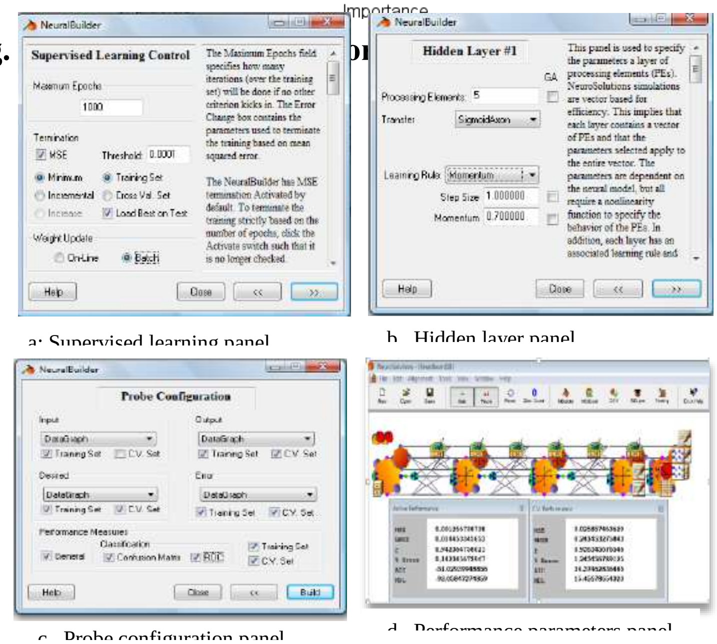
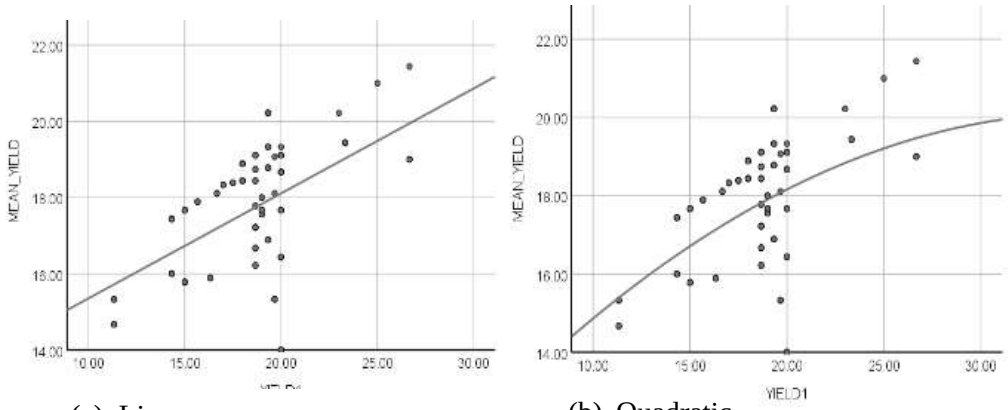
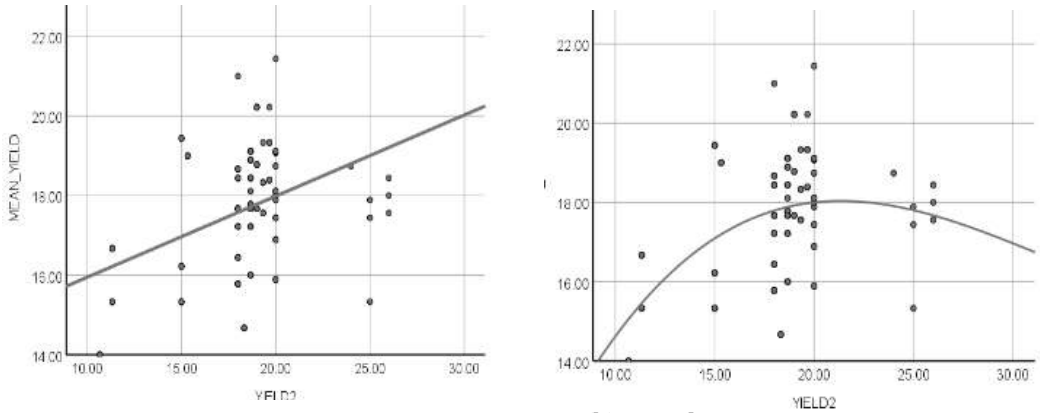


Fig. 3(a-d): ANN training and validation panels for CYF



(a) Linear (b) Quadratic

Fig. 4: Graph of mean cassava yield with yield of planting one stem per stand



(a) Linear (b) Quadratic

Fig. 5: Graph of mean cassava yield with yield of planting two stems per stand

Figs. 4 - 6 depict the plots of CY represented by yield1, yield2 and yield3 produced by planting one stem, two stems and three stems of cassava cultivars respectively at different locations but relatively similar plots of land in Akwa Ibom North West Agricultural zone. In Fig. 4a, the linear interaction between the mean CY with yield 1 obtained by cultivating one stem of cassava per stand is presented. The linear graph shows a positive contribution of yield1 to the mean yield of cassava while the quadratic graph in Fig. 4b reveals that the contribution of yield1 to mean yield has not reached the maximum point as indicated by the maximum curve that is yet to reach the turning point. Similarly, the linear graph in Fig. 5a shows a positive contribution to mean cassava yield by yield2 obtained by planting two cassava stems per stand. However, the quadratic representation in Fig. 5b shows that yield2 has maximally contributed to the mean yield as indicated by the turning point. Fig. 6a shows a positive linear contribution to mean cassava yield by planting three stems per stand. In the quadratic representation of Fig. 6b, the minimum curve shows that planting three cultivars per stand contributed insignificantly to the average yield of cassava.

Evaluation of system performance was carried out using test data set consisting of 250 samples. Actual values and forecasted values obtained from the model were compared. Mean threshold value was obtained from five (5)

agriculturists. The threshold value was used to determine the high, moderate and low yield of cassava forecasting. Values above the threshold were considered as High (H), values equal to the threshold value were considered Moderate (M) and values below the threshold were considered as Low (L). The matching of the actual and the forecasted values was viewed as a correct prediction and the mismatch was viewed as incorrect prediction.

The matching of high or moderate actual value with high or moderate predicted value served as True Positive (TP). The matching of low actual value with low predicted value was viewed as True Negative (TN). The matching of high or moderate actual value with low predicted value was viewed as False Positive (FP), while the matching of low actual value with high predicted value was referred to as False Negative (FN). Samples of outcome from test data set matched with mean threshold value of 17 tones/ha of cassava yield is presented in Table 2. The test data set prediction outcomes for TP, FP, TN and FN were 173, 7, 64 and 6 respectively.

Table 2: Sample of Actual and Predicted Cassava Yield

Test Data ID	Actual Yield	Predicted Yield	Match	Outcome
1	20.22	20.03	HH	TP
2	17.00	17.00	MM	TP
...	...	...	...	...
250	13.44	13.50	LL	TN

Table 3: Performance Evaluation Metrics

SN	Evaluation Metric	Formula	Computation	Value
1	Accuracy	$\frac{TP+TN}{TP+TN+FP+FN}$	$\frac{173+64}{173+64+7+6}$	0.9480
2	Recall, Sensitivity or True Positive Rate	$\frac{TP}{TP+FN}$	$\frac{173}{173+6}$	0.9664
3	Specificity or True Negative Rate	$\frac{TN}{TN+FP}$	$\frac{64}{64+7}$	0.9014
4	Precision or Positive Predictive Value	$\frac{TP}{TP+FP}$	$\frac{173}{173+7}$	0.9611

Some metrics for performance assessment reported in Tharwat (2020) such as (accuracy, recall, specificity, precision) were used to evaluate the CYF model as presented in Table 3. The Accuracy value of 94.80% means that more than 94 forecast out of 100 cases were correct while less than 6 were incorrect. Recall or Sensitivity value of 96.64% implies that less than 4 cases out of 100 cases were wrongly forecasted as high yield while more than 96 instances were correctly forecasted as cassava high yield. Specificity value of 90.14% means that less than 11 cases out of 100 were wrongly forecasted as cassava low yield while more than 90 cases were correctly forecasted as low yield of cassava. Precision value of 96.11% means that on average, 4 out of 100 cases of cassava high yield predictions were wrongly forecasted while 96 cases were correctly forecasted.

Summary

1. FZA, NSH and STP were observed as three most important variables in CY forecasting
2. Other variables such as RFI, WDC, CRD. MNA, CVT, DSC, TMP, PTC, UFE, PLM and NSC arranged in decreasing order of importance were observed to contribute positively to CY forecasting.
3. Planting of one stem of cassava cultivar per stand was observed to contribute more to average yield than planting two or three stems per stand.
4. Hence, this work scientifically settled the contention that existed among farmers on the number of cultivars to plant per stand in Akwa Ibom North-West Agricultural zone, Nigeria.
5. In the ANN model, accuracy, recall, specificity and precision metrics values of 94.80, 96.64, 90.10 and 96.11% respectively were obtained. This indicates high performance capability of the ANN model and its suitability for deployment in the forecasting process.
6. The 94.80% accuracy of the ANN model in this study outperforms the 84 % accuracy of statistical model reported in Ikuemonisan and Akinbola (2021) as well as 0.84 correlation coefficient of the mathematical model reported in Sadenovaa *et al.,* (2021).

Conclusion

In this work, ANN model for cassava yield forecasting has been presented. Investigation into the accuracy of the model was carried out by comparing the actual and predicted cassava yield from the test dataset. System performance evaluation was carried out using four metrics as well as comparison with other forecasting models. Insignificant forecasting error and high percentage accuracy observed in the ANN model validate its efficiency for deployment in forecasting operations. Based on research findings, this work recommends that farmers should plant one stem of cassava cultivar per stand because it contributes significantly to average cassava yield than planting two or more stems per stand. This work has contributed an ANN based CYF model for forecasting the yield of cassava to guide prediction and decision processes in agricultural sector. The model could learn from previous crop yield data and extrapolate into unseen patterns. It could predict the yield of cassava one year into the future. This model is poised to serve as a guide to farmers and agricultural decision makers in planning for storage and marketing of cassava products in event of high yield forecasting as well as planning for alternative source of food for the teaming population in event of low yield forecasting.

The model would guide stakeholders in the agricultural sector towards making informed decisions about storage, purchase or marketing of cassava products to ensure continuous food supply and unceasing income generation. Detailed ANN investigations of cassava yield patterns in response to cassava varieties, soil types, fertilizer and manure types, weather conditions, cultural practices and planting methods are recommended for further research. The flexibility of this model allows adaptability to solve prediction problems in other domains. In order to reduce training time and increase forecasting efficiency, investigations of optimization techniques to guide selection of ANN layers and training parameters are also recommended for further research.

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Computer-supported mathematical analysis, quantitative modelling and elucidation of the dynamics of exploited and unexploited aquatic living resources in tropical waters.

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Abstract: *Some computer-supported mathematical algorithms and quantitative models of fish growth, mortality and recruitment used as inputs in the sustainable management of aquatic living resources notably in tropical waters are elucidated and their applications pointed out.*

Keywords: Fish growth, mortality, recruitment, yield per recruit, fisheries management

CITATION:

Etim, L. (2023). Computer-Supported Mathematical Analysis, Quantitative Modelling and Elucidation of the Dynamics of Exploited and Unexploited Aquatic Living Resources in Tropical Waters. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 660-666

Introduction

One cannot successfully manage anything without first knowing the nature, characteristics and quantity of what is to be managed. This is axiomatic; a self-evident truth, and it explains why one needs to know the types and quantities of goods, say, in a shop before the shop could be managed properly and profitably. Government of countries conduct human population census to enable them manage the economy properly. A poorly managed shop, national economy, etc. will decline and collapse eventually. This same principle applies to natural living resources (e.g., forest resources, fisheries resources); videlicet, the stock or quantity of the resources needs to be known to facilitate their proper management without overexploiting them. Overexploitation would lead to extinction or collapse of resources. One can easily take a census enumeration of any human population but that is not feasible with fishes, because it is impossible to dive into the ocean to take census of fishes most of which are highly mobile organisms. Underwater photography and video recordings are not useful in the quantification of fish biomass.

Estimating the quantity or biomass (live weight) of fish in the ocean requires knowledge of the factors that control the dynamics (changes) of natural fish populations. Growth and reproduction (or recruitment) are the factors that lead to increase in fish populations while mortality (death) leads to a decrease in fish populations. Total mortality in a fish population could be unbundled into natural (e.g. due to predation, sickness, senescence) or man-made (e.g. due to pollution, fishing). Incidentally, the activity of the fisherman has the same effect on the fish population as predation. Here, we assume a close population; that is, there is no immigration into or emigration from the fish population under consideration.

The quantification of growth, recruitment, mortality (natural and fishing mortalities) would help us to model the fish population mathematically. In turn, this would assist in the proper management of the fish stock. A properly

managed fish stock could be harvested year in and year out without depleting such stock. In the ensuing sections, I will take a conspectus look at how growth, mortality and recruitment in fish populations are often modelled mathematically. Such models are useful inputs in the sustainable management of the fish stock.

Growth

Allometric growth. Even intuitively, one can see that there is a relationship between the length and weight of an organism e.g., fish. The weight (W) of a fish is proportional to its length (L) raised to a certain power, say, b; that is:

$W \propto L^b$ … 1

To replace the proportionality sign (∝) with an equality sign (=) in Eq. 1; then, a constant *a* should be introduced into Eq. 1, thus:

$W = aL^b$ … 2

W in Eq. 2 is the weight of the fish, L the length, *a* is a constant and *b* a coefficient. The graph of Eq. 2 is upwardly curvilinear in shape. The linearization of Eq. 2 through log transformation would yield the following.

$\log W = \log a + b \log L$ …3

Eq 3 is actually *a* straight line graph of the form:

$Y = \log a + b \log X.$ … 4

By regressing various values of weight (W) against their corresponding values of length (L); then, *a* is the Y-intercept while b is the slope of the straight line graph. The logarithmic transformation of Eq 2 into Eq 3 introduces an error for *a* and *b* values together with their standard errors when ordinary least-square regression is utilized in solving Eq 3. More reliable estimates could be obtained by using non-linear least square regression which is executed iteratively in directly solving Eq 2 for *a* and *b* values and their standard errors.

The *a* coefficient is also called the *initial growth constant.* It is equal to W if L (in Eq. 3) is zero. It is not possible to know when the length of the fish was zero. Thus, the *a* coefficient has more mathematical value but no biological value or meaning. The coefficient *b*, which is the slope of the straight line graph, is a more biologically meaningful parameter. It represents the rate of change in weight per unit change in length. For length weight-relationship in fishes, *b* is often close to 3 (Bertalanffy 1951) and may range between 2.5 to 3.5 (Carlendar 1969, 1979) or in some cases from 2 to 4 (Pauly and Gayanilo 1997). For bivalves, the values may fall between 2.5 and 4.5 (Wilbur and Owen 1964).

When *b* = 3, then the growth in weight is isometric. In such a case, weight growth is proceeding in the 'same' dimension as the cube of the length (Pauly 1984) as would occur in fishes whose body form and specific gravity do not change as they grow (Ricker 1975). If $b \neq 3$, (that is, if b is not equal to 3), then growth in weight is termed allometric; implying that weight growth proceeds in a 'different' dimension from L^3.

von Bertalanffy growth function: Growth is the change in size (length, weight, volume) of fish over time. Linear measurements (length) are generally easier and cheaper to take than weight measurements. In the body of any living organism, there are various chemical processes (metabolism) that take place. Some metabolic processes would lead to building-up of the body (anabolism) but others will lead to breaking-down (catabolism) of body substances. Growth is the net result of these two opposing processes:

Growth = (build up) – (break down) … 5

During the build-up processes (as in Eq 5), a change in fish weight per unit time (dw/dt) is proportional to the weight of the fish (W) raised to a certain power *d*, thus.

$\frac{dw}{dt} \propto W^d$ … 6

Inserting a proportionality constant *H* into Eq 6 will lead to:

$\frac{dw}{dt} = HW^d$ … 7

H in Eq 7 is the coefficient of anabolism and HW^d is the weight gained from anabolism in a unit time.

For the break-down processes (in Eq. 5), it is taken that the rate of weight loss is proportional to the weight of the fish

$$\frac{dw}{dt} \propto -W \quad \ldots 8$$

Given a proportionality constant of *k*, then Eq 8 becomes:

$$\frac{dw}{dt} = -kW \quad \ldots 9$$

Where k is the coefficient of catabolism and the term -kW represents the weight lost in a unit time. The negative sign in Eq. 9 symbolizes a loss, a decrease or a decay.

Given the values of $\frac{dw}{dt}$ in Eq 7 and Eq. 9 we can re-write Eq 5 as

$$\frac{dw}{dt} = HW^d - kW \quad \ldots 10$$

With apposite physiological assumptions and "serious mathematics", von Bertalanffy (1938) solved Eq 10 essentially through integration to obtain the following:

$$L_t = L_\infty [1 - e^{-K(t-t_0)}] \quad \ldots \quad 11$$

Eq 11 is eponymously called the "von Bertalanffy growth equation" or the "von Bertalanffy growth function" (VBGF). For Eq 11, L_t = length at a given age t, L_∞ = asymptotic length (the mean maximum length the fish would ever reach assuming that they would grow indefinitely and given the ecological peculiarities of that habitat), K is a growth constant which indicates the speed at which the fish grows towards L_∞, t_0 is the age of the fish when its length was zero (it's impossible to know when the fish length was zero – is it in the ovary, as an egg, or just at the time of hatching? So, t_0 has a mathematical meaning not biological meaning). When expressed in terms of weight, Eq 11 assumes the form:

$$W_t = W_\infty [1 - e^{-K(t-t_0)}]^3 \quad \ldots \quad 12$$

In Eq. 12, all parameters are as defined for Eq 11 except W_∞ which is the asymptotic weight. In fisheries science notably fish population dynamics, VBGF is the most widely used model for quantifying fish growth. Further details of the VBGF could be found in Etim (2001a) which includes its advantages and disadvantages and how to fit it to data.

Seasonalization of VBGF

In their aquatic habitats, fishes are affected by a multiplicity of environmental factors (food availability, temperature fluctuations, etc.) which vary seasonally; consequently, they influence the growth of fish to also vary seasonally. Nevertheless, VBGF (Eq. 11 and 12) does not capture the effect of changing season on growth. The influence of season on growth is very real and remarkable notably in temperate regions where growths could slow down or are completely halted during winter periods but are very fast during summer months. Seasonalization of growth equations was precipitated by the realization that mathematical growth models which do not capture the effects of season on growth will fail to mirror salient aspects of fish growth (Pauly 1990).

The first person to modify the VBGF so that it takes the effect of changing season on growth into consideration was Ursin (1963). Then, Pitcher and MacDonald (1973) was followed by Daget and Ecoutin (1976). After, many authors (Cloern and Nicholas 1978, Antonie *et al* 1979, Pauly and Gaschutz 1979, Hoenig and Chaudara-Hanumara 1982, Sega 1984, Appeldoorn 1987, Moreau 1987, somers 1988, Sorriano and Jarre 1988, Soriano and Pauly 1989, Chaudar Hanumara and Hoenig 1990, Gaschutz *et al* 1980) suggested their modifications, or methods and approaches of fitting them to data.

Pauly and Gaschutz (1979) proposed a seasonalized VBGF that integrates a sine wave function into the original VBGF (Eq. 13) thus:

$$L_t = L\infty (1 - \exp - K(t - t_0) - CK/2\pi \sin 2\pi(t - t_s)) \quad \ldots 13$$

Later, Somers (1988) modified Eq. 13 to:

$$L_t = L_\infty [1 - e^{-k(t-t_0) - (CK/2\pi \sin 2\pi(t - t_s) + CK/2\pi \sin 2\pi (t_o - t_s)}] \quad \ldots 14$$

For Eq. 13 and 14, L_t, L_∞, t_o, K and t are as already defined in Eq 11, C is a constant which indicates the intensity or amplitude of the sinusoidal growth oscillations. Once in a year during winter, when growth completely halts (i.e., when dL/dt = 0), then C = 1 and Eq. 14 would reverts to the VBGF (Eq. 11). But, if growth simply slows down without stopping; then, C may take any intermediate value between 1 and 0. t_s is the onset of first growth oscillation relative to t = 0.

Mortality

Mortality reduces the population size of a stock. Unlike growth rate, mortality rate is a population attribute; thus, we can talk of the death of an individual but not the death rate of an individual. Total mortality rate Z could be decomposed into natural mortality rate M and fishing mortality rate F in line with Eq. 15.

$$Z = M + F \quad \ldots 15$$

In a virgin stock where there is no fishing (F = 0); then, Z = M in Eq 15. By plotting the number of fish in a certain cohort against time (in years), the graph will slope from left to right indicating a decrease (or decay) in numbers over time.

Eq. 15 is a mathematically useful approach in expressing such decay (decrease) in population numbers.

$$N_{i+1} = N_i \bullet e^{-Z(t_{i+1} - t_i)} \quad \ldots 16$$

Here, N_i is the initial number of fish when time was t_i, N_{i+1} is the number of fish that remain after time t_{i+1} had elapsed, Z is the instantaneous rate of total mortality. Eq 16 is often referred to as the Single Negative Exponential Mortality model or Single Negative Exponential Decay model. One advantage of expressing mortality in terms of instantaneous rates is that they are additive; that is, we can add or subtract them (see Eq 15). One assumption of Eq. 16 is that there is one instantaneous mortality rate value Z for all age or length classes; but, that is far from reality. In reality, mortality rate of juveniles are greater than those of adults. And normally, mortality rate of normal adults are less than those of senescent adults.

By regressing Ni+1 against Ni (in Eq 16), we can determine Z as the slope b of the right descending arm of the graph with sign changed. This is the so called catch curve analysis.

Natural mortality. The instantaneous rate of natural mortality M in Eq. 15 is easily determined by the model put forward by Pauly (1980)

$$\log_{10} M = 0.0066 - 0.279 \log_{10} L\infty + 0.6543 \log_{10} K + 0.463 \log T \quad \ldots 17$$

with r = 0.847

Eq 17 is eponymously called "Pauly's M equation" and in terms of growth in weight it takes the form:

$$\log M = 0.2107 - 0.0824 \log W\infty + 0.6757 \log K + 0.4627 \log T \quad \ldots 18$$

with r = 0.845

According to Pauly (1980), Equations 17 and 18 provide highly reliable estimates of M. The models were derived from data from 175 different fish stocks which covered 84 different species in both freshwater and marine environments which ranged from the polar through temperate to tropical aquatic ecosystems. These models are very widely used throughout the world especially in the tropics probably because they had been incorporated into at least two fisheries software programmes (ELEFAN and FiSAT) and has been the model of choice in FAO/DANIDA/ICLARM training courses in different world regions. The input data for the derivation of these Eq. 17 and 18 did not cover crustaceans and molluscs; so, the models may not give bias-free results when applied to a crustacean or molluscan species. In fact, Sparre and Venema (1992) is of the opinion that these models should never be used for molluscan and crustacean species. The L∞ used in this model

pertains to total length; hence, other length measurements e.g. standard length or fork length may give biased results.

The quality of input data used by Pauly (1980) in deriving these models is a source of concern to many. For example, the mean annual surface water temperature T used for many of the data points were approximations read from world climate atlas and charts. Some of the M values used as input in the multiple regression were "observations" which "can be questioned" (Sparre and Venema 1992). Roff (1984) believes that Pauly's equation has "unfair" advantage because the predicted values are the same as those used to estimate the coefficients. Generally, Pauly M equation underestimates M for polar fishes and overestimates M for clupeid fishes (Pauly 1980). A conversion factor of 1.3 and 0.8 should be applied to polar and clupeid fishes respectively. For polar fishes, the measured real environmental temperature T must be converted to effective physiological temperature using Fig 1 in Pauly (1980). Despite these criticisms and shortcomings, Pauly's M models continue to gain popularity around the world essentially because no one has proposed a better model to replace it. Etim (2001a, b) contains other methods for the estimation of natural mortality in fish populations. Eq 17 and 18 were derived by Pauly[1] as an aspect of his PhD thesis in the University of Kiel (Germany).

Fishing mortality: After parameterizing Z from Eq 16 using the catch curve procedure, and M from Eq 17 or 18 using the Pauly's M equation, F (the instantaneous rate of fishing mortality) could be determined through a rearrangement of Eq 15 thus:

$$F = Z - M \quad \ldots 19$$

Recruit:

One use of Z, F and M is that they are necessary as input data for estimating yield through the Beverton and Holt (1957) model which enables the prediction of long term yield in a scenario where there exist various fishing regimes. Recruits are young fishes which are at (or have swum into) the fishing ground and are big enough to be captured by the fishing gear. After being hatched, the young fish which constitute the cohort will move to the fishing ground at age t. This number of fish that move to the fishing ground constitute the recruitment R into the fishery. Having reached the fishing ground they would have to reach a certain age t_c before they are big enough to be captured; therefore, t_c is the age at first capture. Generally, recruits to a fisheries are in units of yield per recruits per time; for example, grammes per recruit per year (Gayanilo and Pauly 1997). Yield is catch in terms of weight. The model derived and put forward by Beverton and Holt (1957) for the computation of yield per recruit (Y/R) takes this form:

$$Y/R = F.e^{-Mr2}\ W\infty \left[\frac{1-e^{-Zr3}}{Z}\right] - \left[\frac{3e^{-Kr1(1-e^{(Z+K)r3}}}{Z+K}\right] + \left[\frac{3e^{-Kr1(1-e^{(Z+2K)rr3}}}{Z+2K}\right] - \left[\frac{e^{-3Kr1(1-e^{(Z+2K)rr3}}}{Z+3K}\right] \quad \ldots 20$$

Where, Z = total mortality (F + M); r1 = $t_c - t_0$; r2 = $t_c - t2$ and r3 = $t_{max} - t_0$; W∞. K, and t_0 are the VBGF parameters as defined for Eq 11 and 12; tc is the mean age at first capture; tr is the mean age at recruitment; t_{max} is the maximum age or longevity of the fish species in that habitat.

[1] See Etim (2006) for more on the scientific works and achievements of Prof Dainel Pauly who has been variously described as "an iconoclastic scientist", "the pope of tropical fisheries", "the living legend of science", "a genius", "the most highly cited fisheries scientist of his generation" and "the most flamboyant scientist to be seen on the horizon in this (20th) century". The venerable scientist Prof Hilborn (University of Washington, Seattle in the USA) sees Pauly as an "immensely charismatic, articulate, big picture guy". In 2003, the Scientific American was the first to list Pauly among the "50 Most Influential Scientists" in the world; later, this was followed by a multitude of newspapers, magazines, journals, academic bodies, institutions, organizations and companies. Etim (2006) is an 8-page article that contains my impressions of and personal encounters with Prof. Daniel Pauly who, incidentally, is my role model.

Under high exploitation intensity, the impact of t_{max} could be negligible. But granted we set $t_{max} = \infty$; then, Eq. 20 will become

$$Y/R = F.e^{-Mr2} W\infty \left[\frac{1}{Z}\right] - \left[\frac{3e^{-Zr1}}{Z+K}\right] + \left[\frac{3e^{-Kr1}}{Z+2K}\right] + \left[\frac{e^{-3Kr1}}{Z+3K}\right] \quad \ldots 21$$

Eq. 21 is the famous Beverton and Holt (1957) yield per recruit (Y/R) equation. This is a steady state model which relates the state of the stock and its yield when the same fishing pattern is extant for a very long time that all fishes alive have been exposed to it ever since they were recruited.

Fisheries managers are in a position to influence F and tc in Eq 21 in the sense that F is an indicator of fishing effort and tc relates to the selectivity of the gear (which in terms of nets is a question of mesh size). In simple terms, this reduces the management of the stock to controlling the effort (number of boats, number of gears, hours spent fishing) and age (or length) at first capture. The Y/R in Eq. 21 is in terms of absolute values of grammes per recruit per year. The problem of parameterizing Eq 21 is that the input data are difficult to obtain. To solve that problem, Beverton and Holt (1964) explored further mathematical options which lead them to propose a dimensionless ratio they called "relative yield per recruit" in Eq. 22.

$$Y'/R = EU^m \left[1 - \left(\frac{3U}{1-m}\right) + \left(\frac{3U^2}{1+2m}\right) - \left(\frac{U^3}{1+3m}\right)\right] \quad \ldots 22$$

Where $U = 1 - (Lc/L\infty)$, $m = (1 - E)/(M/K) = K/Z$, E is the exploitation rate, M the instantaneous natural mortality rate and K the growth coefficient or curvature parameter of the VBGF. Eq. 22 has fewer parameters than Eq. 21 and is particularly useful in studying the effectiveness of regulating mesh size in a fisheries. Y'/R is a function of E and U and the only thing needed for its determination is M/K.

Acording to Gayanilo and Pauly (1997), the Y'/R in Eq 22 can be transformed back to Y/R in Eq 21 using Eq 23.

$$Y'/R = Y/R \bullet e^{M(t_r - t_o) / W\infty} \quad \ldots 23$$

Here, M is the instantaneous rate of natural mortality, tr age at recruitment and t_0 the weight at zero age.

FiSAT (Gayanilo and Pauly 1997) contains routines for the parameterization of all the models (and more) mentioned in this article.

Management application:

Tropical fisheries are multi-species and multi-gear fisheries. For example, there are about 29 fish species in the Cross River estuary. This poses a unique problem in the management of the fish stock. If a fish cohort is caught when they are still very young, the fishes will not have the opportunity to reproduce before they are caught. This may lead to a reduction of stock. Additionally, the catch will be made of many but tiny fishes which will not attract high price and will be difficult to process. To avoid this problem, the fish should be left to grow bigger and old before they are caught. But the risk is that most of the fishes would die of disease and senescence even before they are captured. In that case, the catch will consist of few very big fishes. The solution is to catch the fish when they are not too young or too old. Knowing when the fish cohort is not too young or too old is difficult. That's where the Beverton and Holt models come to the rescue.

A most widely used quantitative tool in managing any fishery is the Beverton and Holt (1957) model which finds useful application in yield (catch in weight) prediction based on recruit numbers. The model facilitates the understanding of the interrelationship between fish mortality and size of the population and by so doing it helps fisheries managers in determining the apposite amount of fishing effort to be applied to ensure stock

sustainability. The model could be used in estimating MSY (maximum sustainable yield), assess impact of changes in fishing pressure, compute mortality rates, habitat quality on the population. The influence of Beverton and Holt on fisheries management is enduring (Jennings and Dulvy, 2008) and it is to their credit that almost none of their ideas have been overturned by half a century of subsequent research.

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Guidance And Counselling: A Panacea For Saboteurs Of Sustainable Economic Development In Nigeria

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Abstract: *Global economic volatility calls for synergy across various sectors and professions to promote responsible actions by all and sundry towards strengthening the three pillars of sustainable economic development namely, social sustainability, economic sustainability, and environmental sustainability. Professional guidance and counselling has, up till now, been the missing tool in the struggle for sustainable economic development in Nigeria whereas counselling services have been found to be very potent in identifying and addressing multifarious issues of everyday life. A snapshot of Nigeria's economic profile shows that much of the setbacks experienced are rooted in self-sabotaging attitudes and behaviours of people at various levels of responsibility in society. This article identifies some of these endemic attitudinal and behavioural saboteurs and proffers strategies implementable through professional counselling services to engender attitude change and foster behaviours that would strengthen the pillars of sustainable economic development in Nigeria.*

Keywords: Sustainable economic development; Guidance and counselling; Social sustainability; Economic sustainability; Environmental sustainability

CITATION:

George, I. N. (2023). Guidance and Counselling: A Panacea for Saboteurs of Sustainable Economic Development in Nigeria. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 650- 657

Introduction

Professional guidance and counselling has, in its modern history, provided a host of diversified and specialised services in response to problems in all areas of life; including mental and physical health issues, intra- and inter-personal challenges, social and communal issues, academic and occupational issues, marital and family issues, legal issues, and financial issues. Generally, the scope of professional guidance and counselling has expanded rapidly to carter to diverse and emerging needs of the society. As economic volatility persists globally, it is undeniable that every profession must contribute their quota towards improving the economic profile of Nigeria. The question thus beckoning for an answer becomes whether there is anything professional counsellors can do, through their professional practice to improve the economic profile of Nigeria?

Apparently, professional guidance and counselling has, up till now, remained the missing tool in the struggle for sustainable economic development in Nigeria. The current discourse on Nigeria's economic profile would not be complete without an exposé on the prospect of professional guidance and counselling in combating known saboteurs of sustainable economic development in Nigeria both at individual and collective levels of society. The focus of this article is to examine the factors that have hitherto undermined various aspects of the nation's economy and proffer strategies implementable through professional guidance and counselling services to curtail these saboteurs.

The Concept of Sustainable Economic Development

The Monash Sustainable Development Institute (2023) projects the concept of sustainable development as "development which meets the needs of the present without compromising the ability of future generations to meet their own needs." This conceptualisation is built on the premise that the global push for economic growth has attendant costs which often manifest as environmental degradation and social disparities. The institute opines that global population growth puts enormous pressure on the biosystem and social equity. Thus, sustainable development calls for the adoption of more responsible consumption and production patterns; a strategic response to cater for a more balanced approach to growth that facilitates and enhances development across the three core pillars namely: social inclusion, environmental sustainability and economic prosperity.

Social sustainability: This pillar focuses on the need to ensure that economic development benefits all members of society and does not create or exacerbate inequalities. This involves promoting social justice, protecting human rights, providing access to basic services such as healthcare and education, and creating employment opportunities for all.

Environmental sustainability: This pillar emphasises the need to use natural resources in a responsible and sustainable manner, and to minimise the impacts of economic activities on the environment. This involves promoting sustainable production and consumption patterns, reducing pollution and waste, protecting biodiversity and ecosystems, and adapting to the impacts of climate change.

Economic sustainability: This pillar emphasises the need to promote long term economic growth that is both financially viable and socially and environmentally responsible. This involves encouraging innovation, promoting efficient resource use, creating resilient and diversified economies, and promoting responsible business practices.

Together, these three pillars of sustainable economic development seek to promote a balance between economic growth, social wellbeing, and environmental protection to ensure a sustainable future for current and future generations. A point of interest which also provides the needed entry point for professional guidance and counselling is the fact that these three pillars make more of behavioural demands on all players than anything else; it emphasises what each person has to know and do than what systems should be involved in the process. It is thus safe to assume that economic sustainability is first and foremost an attitude, leading to responsive and consistent behavioural outcomes both at the individual and collective levels of society. Professional guidance and counselling services would thus facilitate the development of such desirable attitudes and assist individuals unlearn any identified barriers or dispositions that are inimical to the goals of sustainable economic growth.

Nigeria's Economic Profile

A cursory look at the economic profile of Nigeria alarms one to some major cracks which have, up till now, been insidious to various efforts at patching them. While being touted as the largest economy in Sub Sahara Africa, a 2021 report from the Central Intelligence Agency (CIA) shows that the economic diversification and strong growth that Nigeria has witnessed have failed to translate into significant decline in poverty levels as over 62% of Nigeria's 200+ million people still live in extreme poverty. The report add that despite the enormous human and material resources Nigeria is blessed with, especially oil and gas, the economy is crippled by "inadequate power supply, lack of infrastructure, delays in the passage of

legislative reforms, restrictive trade policies, an inconsistent regulatory environment, a slow and ineffective judicial system, unreliable dispute resolution mechanisms, insecurity, and pervasive corruption" (CIA, 2021).

Arguably, prevailing impediments to the socio-economic development of Nigeria are not dissimilar to what obtains in other climes. The 2022 Corruption Perceptions Index (CPI) shows that most countries are failing to stop corruption in spite of concerted efforts to do so; with Nigeria sitting at 150th position out of 180 countries on the global corruption ranking (Transparency International, 2022). In the aspect of human development, the 2021/2022 Human Development Report finds Nigeria far down at 163rd position with a Human Development Index (HDI) value of 0.535 (United Nations Development Programme, 2022). The 2018 Global Multidimensional Poverty Index (MPI) estimations show that Nigeria has the second largest (97 million) population of people living in multidimensional poverty (Alkire, Kanagaratnam, and Suppa, 2020).

In view of the trends observed above, it is incontrovertible that sustainability in the aspect of economic development should be addressed as a national emergency situation. As earlier stated, the pillars of sustainability require consistent responsible behaviour from all actors. It is therefore imperative to examine some potential saboteurs of sustainable economic development in Nigeria with a view to proffering appropriate counselling interventions.

Saboteurs of Sustainable Economic Development in Nigeria

Several saboteurs of sustainable economic development, which manifest in the form of self-sabotaging attitudes and behaviour, have systematically held millions of rather productive Nigerians hostage, leading to multidimensional losses for individuals and the society at large. Before discussing some of these attitudes and behaviours, it is of essence to expound on the concept of self-sabotaging behaviour. Self-sabotaging behaviour refers to intentional actions (or inactions) that undermine progress and prevents the accomplishment of long-term goals and undermining personal values (Brenner, 2019). Berg (2015) posited that self-sabotage is "insidious, profound, and universal." Self-sabotage often begins as a coping function which people use to deal with stressful situations and past traumas. Unfortunately, it typically makes problems worse and limits a person's ability to successfully move forward in a healthy sustainable way (Field, 2023).

Also known as behavioural dysregulation, self-sabotage can be conscious or unconscious depending on level of awareness. An example of conscious self-sabotage is deciding to employ new cadets into an ageing security agency, despite a goal to strengthen communal security. Unconscious self-sabotage happens when a goal or value has been undermined but not initially recognized. The Central Bank might wait until the last minute to work out modalities for the return of old notes even though it is apparent that the population served is very large and is prone to violent protests due to experienced difficulty with a defective process to that effect. Wilson (2021) identifies cognitive dissonance as another dimension of self-sabotage. Cognitive dissonance is the internal imbalance or discomfort experienced when words or actions do not align with beliefs and values. When this happens, people act to ease the discomfort by changing their words or behaviours or by reframing their goals and values.

While it seems unlikely that anyone would intentionally sabotage themselves, this has become a modern reality, with caustic consequences. Much of the economic woes that persist in Nigeria result from self-sabotaging behaviours of individual and group of actors in responsible sectors of society. The following are

some attitudes and dispositions which the author considers saboteurs of sustainable economic development in Nigeria:

- **Get-rich-quick Tendencies:** Due to prevailing socioeconomic stress and dearth of opportunities for gainful socioeconomic engagements, many people, especially the youth population are disposed to schemes that promise them instant wealth with minimal investment of resources, such as money, time and effort (Adebayo, 2013; Dan-Awoh, 2022; Obasi, 2021; Onoh, 2018). This disposition, which may appear to be adaptive, has caustic consequences in the long haul. In recent times, many Nigerians have fallen prey to various Ponzi schemes losing humongous sums to fraudsters who masquerade as investment advisors and marketers (Adaramewa, 2023). While it is commendable that the government at various levels is responding appropriately with advisories against these schemes (e.g. Oji, 2021; Olaniran, 2021), it is sad that not much has been done to contain the menace of another cankerworm: sports betting. Sports betting has enslaved millions of Nigerian youths with the false promise of making instant financial breakthroughs through huge winnings if they commit some amount of money on sports predictions (Streeter, 2022). Ironically, the country continues to lose billions of naira annually to these bookmakers in exchange for a paltry sum in the guise of taxes; plunging scores of young, rather productive youths, into depression, suicide, hopelessness, and abject poverty (cf. Fazio, 2021; Njemanze, Nwokporo, Agha, and Nwosu, 2020).
- **"Soft work" Tendency:** It appears that the vast majority of young and able persons do not want to work anymore, even though they recognise their need for sustenance and needs satisfaction. This occupational lethargy has led to the rise of fraud in various sectors of society. Apparently, the money swindled from others become easy income, hence the catchphrase "soft work" is being used by youths to glorify and promote internet fraud and other forms of financial crimes (Elgbadon and Adejuwon, 2015; Michael, 2019). This self-destructive trend has seen many youths abandon formal education and the quest for gainful employment to pursue internet fraud only to end up mentally deranged due to money rituals, or dead through extra-judicial killings or languishing in custodial centres where they waste their prime years serving jail time (Bamigbola, 2021). Among the employed, "soft work" tendencies my manifest in attitudes that undermine productivity such being self-sparing when it comes to level of involvement in workplace tasks, leading to loss of manhour and productivity. Firms and institutions of government that fail to keep this tendency in check through various internal supervisory mechanisms may suffer bankruptcy in the long haul as a result of this trend (Bouzid, 2016). Generally, the quest to do less work while earning more rewards is a cankerworm capable of significantly undermining sustainability in various aspects of economic growth.
- **National Cake Syndrome:** Evolving originally as a common slang describing the equitable sharing of national common wealth with people across all divides, especially proceeds from crude oil exploration, the concept has in modern times become a justification for embezzling public resources by those in position of trust such as public office holders (Nche, 2011). The tendency is to illegitimately take for oneself or cronies juicy government contracts, appointments, assets, or funds with the assumption that one has been blessed with the opportunity to get a share of the national cake. This tendency has led to untamed corruption in public institutions.

This significantly impedes sustainable development as the means of survival continues to be controlled by a few elites who ordinarily would not even be able to exhaust the stolen resources, depriving the vast majority of basic everyday necessities.

- **My turn/Our turn Syndrome:** The appeal of taking turns in various public spaces and functions evolved originally as an adaptive function in response to the diversity of the people and culture of Nigeria (Premium Times, February 8, 2022; Vanguard, March 28, 2022). This has sadly degenerated into a caustic syndrome, exacerbating religious, and racial differences and resulting in the sacrifice of efficiency for mediocrity on the alter of tribalism, religious diversity and what not. The sad outcome has been failure to sustain development trends across regimes of government and administration in various sectors of the economy. When people take "their turn", they focus on discrediting the previous regime of administration and attempt to toe novel paths of developments instead of building on and continuing from where the previous stopped (Agbazuere, 2020; Ayo-Philip, 2018). This self-serving tendency has become Nigeria's worst nightmare, a cankerworm that can only be slayed using specialised psychological services, guidance and counselling.
- **Job Seeker Syndrome:** The era of job seeking has long headed to the exit door as the global economy now depends more on production, venture creation and entrepreneurship than on administration. This is largely due to the fact that the major employers of the past century which were government establishments do longer have the capacity to mop up job seekers in the labour market as the later are supplied in excess of what is needed in modern government establishments (Pizzinelli and Shibata, 2022; Pologeorgis, 2022). Sadly, the vast majority of individuals are yet to make the important switch from obtaining an education for the purpose of certification and subsequent administrative roles in government establishments to obtaining education with the aim of skills training for self-reliance, venture creation and entrepreneurship. Even the educational curriculum has been sluggish in catering for this paradigm change. This trend leaves a heavy burden of unemployment on the society with a great number of potentially productive youth underemployed and unemployed; many services and productivity gaps unfilled and key production and services sectors of the economy perpetually outsourcing manpower from expats (Schreiber, 2022).
- **Chronic Consumerism:** Many people believe that quality of life and happiness depends on their capacity to consume a vast chunk of available goods and services and accumulating material resources. Thus, they see this as a desirable goal and go to great lengths to fulfil them even to the detriment of economic growth and development at thee micro and macro level of society (Hayes, 2022). Unless this trend is corrected and the country moves from a consuming to a producing economy, it would be difficult to sustain the little gains current economic development drives have recorded. Sustainable economic development requires responsible consumption at all levels of the economy; where available resources are not being squandered to depletion by a few elites but shared equitably across social divides, and harnessed in a manner that minimises damage to the environment (Barber, 2021).
- **Unguided Schooling:** Formal education is highly prized in Nigeria. Arguably, education remains the key to success as no nation can grow beyond her system of education

(Onyebueke, 2014). Notably, current trends in globalisation, industrialisation, and digitisation require that education responds adequately to emerging needs of society in terms of manpower development and preparations for productive and functional living both at a personal and communal level. Sadly, the ragtag system of school guidance and counselling observed in Nigeria fails to provide the needed awareness and support for students to fashion their education goals towards the needs of society for socioeconomic relevance (Raji, 2019). A critical analysis of the yearly admission and graduation data would show that much of the education obtained, especially in the tertiary institutions, are for occupations with low manpower needs whereas the critical areas remain neglected (Cournoyer, 2016; Oluyomi and Adedeji, 2012). This trend significantly undermines the quest for sustainable development as the services, technology, and production sectors continue to grapple with dearth of skilled human resources.

Counselling for Sustainable Economic Development

Professional guidance and counselling services are very potent when it comes to repositioning individuals and groups towards greater self-awareness, self-direction, and responsible living. In response to the need for responsible attitudes and behaviours on the part of all and sundry towards sustainable economic development, the three pillars of sustainable development could be supported by professional counsellors as follows:

- ***Social sustainability:*** Outreach programmes targeting socially excluded populations should be championed by professional counsellors. Such programmes will identify underserved sectors of society and their needs and advocate for inclusion through systematic initiatives advocating not just policy change as hitherto obtained, but also facilitate needed attitude change on the part of implementers to engender social equity, accommodate diversity and sustain inclusion. It will also counteract self-serving tendencies like the "national cake" and "my/our turn" syndromes.
- ***Environmental sustainability:*** Public awareness programmes should be championed by professional counsellors to foster compliance with public health and safety policies and initiatives. These programmes of awareness with adopt approaches that address barriers to public awareness at the individual level and facilitate compliance through tailored behaviour change initiatives at the individual and community level to address prevailing needs for environmental sustainability. It will also counteract tendencies towards chronic consumerism and similar greedy squandering dispositions.
- ***Economic sustainability:*** Financial education and counselling should be integrated into career development programmes at all school levels as a part of the total education experience of learners. This will impart from the earliest possible level of economic development the critical skills needed for consistent, profitable economic growth and risk management. It will also promote self-reliance through venture creation and entrepreneurship and counteract the tendencies towards "soft work" and job-seeking. This will foster long term economic growth that is both financially viable and socio-environmentally responsible.

Conclusion and Recommendations

A huge gap exists in literature on the roles of professional counselling in sustainable economic development. A look at the economic profile of Nigeria and the brief exposé on the attitudinal and behavioural saboteurs of sustainable

economic development in Nigeria provides an astute counselling professional a periscope on the quintessential roles professional counsellors have to play towards the sustainability of Nigeria's economic growth.

It is thus recommended that economists forge mutually beneficial partnerships with counsellors when studying economic trends, developing and implementing policies, and addressing consequential issues. Professional counsellors have the know-how needed to effect the critically desired attitude change and engender needed responsible behaviours that would translate to sustainable economic growth and development for Nigeria.

It is further recommended that the government at all levels revisit their responsibility to provide such education that would produce citizens prepared for functional living in the society. Such education must have as a well organised and function programme of school counselling as an integral part of the total educational experience of the learners. This will go a long way to build attitudes and behaviours that promote social, economic and environmental sustainability from the earliest possible opportunity as no economy can grow beyond the level of her education.

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PROMOTING E-LEARNING IN BUSINESS EDUCATION BEYOND THE ERA OF COVID-19 PANDEMIC IN NIGERIA

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Abstract: *The use of e-learning is prioritized in Nigeria's current strategy for teaching and learning across all disciplines. Ideally, no effective educational programme can function without modern technologies. This is the case because they are crucial to instruction and learning that aims to create digital natives. Students today inhabit a society that is essentially dominated by technology. They deal with concerns and problems that have technological roots throughout their entire lives. The application of digital media in business education can help students gain problem-solving abilities, a positive mindset, an appreciation and interest in science, as well as technology literacy. These abilities are acquired through a combination of technology-enabled education and general life preparation for young people.*

Key words: Promoting, E-learning, Business Education, Covid-19, Pandemic
Citation:
Undie, S. B.and Udo, S. D. (2023). Promoting E-Learning in Business Education Beyond the Era of Covid-19 Pandemic in Nigeria. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 641- 649

Introduction

Computers have given humanity so much power, abilities, and capabilities that one can today claim of being able to accomplish everything on this planet including teaching and learning. So much has been achieved through the incredible functioning and operating capacity as well as substantial advancements in electronics and communication technology. Education and learning erstwhile restricted to human variables—teachers and students—teaching and learning are no longer limited by conventional barriers, techniques, and tools and have steadily grown into a topic of technological advancement. The field of teaching and learning has been nearly revolutionized by computer operation and networking. Instead of being completely reliant on the teachers' guidance and the content knowledge contained in printed materials, students can now use the device's repository and networking capabilities to not only discover source material, but also to interact with it digitally in the same way that they would in a real-world classroom. By interacting electronically, students can acquire crucial knowledge and abilities in nearly every imaginable discipline at their own pace. The secret to digital education is e-learning.

E-learning is a modern style of education that uses electronic technologies to facilitate learning. Remote education, distance learning, online learning, internet learning, and other terms may be used, but they all refer to the same thing. Online learning offers teachers and students a wide range of possibilities. Through the use of e-learning technology as a teaching tool, students can learn important skills and information in almost any field conceivable in

their own time. The majority of the internet-based classes may be self-paced, enabling learners to fit learning in personal schedules instead of planning daily routines during class times. E-learning offers more flexibility, better quality, and more knowledge than traditional educational methods, which rely heavily on textbooks and printed materials. As a result, people have been able to efficiently search out, gain, then share knowledge at a small expense. E-learning has the ability to help students with a wide range of academic objectives, conceptual as well as pragmatic, in both solo and mutually supportive settings. It can serve as a great repository of information and knowledge for all disciplines included in the curricula. In today's fast-paced world, we can only survive by equipping ourselves to keep up with the rate of change and technological advancement, and e-learning is the requirement of the hour.

Individuals are becoming even more interested in e-learning than before. This is more so because of the pandemic of Covid-19, which has forced billions of pupils to adopt new ways of learning. To stay up with the times, schools have embraced new methods. In some ways, by promoting e-learning, the traditional academic education system has normalized it. E-learning is gaining in popularity due to the rapid growth of the World Wide Web and Internet in this era of information and communication technologies. A computer and an internet connection are all that an e-learner requires. The internet has grown thousands of times in size since its inception two decades ago. Currently, there are about 60 million host's systems online, serving approximately 200 million people throughout more than 200 nations and regions (Cathy and Fara, 2020). However, it is uncertain whether staff members and students in Nigerian education institutions are receptive to and are also leveraging the academic potential of advanced educational technologies.

In contrast to sophisticated countries of the world, numerous educators and learners in poor economies seem to be oblivious of and neglect to use all the massive possibilities of the World Wide Web for learning, which has led to the growing influence of printing and paper-based materials innovations, in-person dialogues, and print materials in our education sector (Manir, 2007). Manir (2007) went on to say that, despite the Internet and e-learning technology, most learners and educators still use conventional teaching techniques of completing academic duties, despite the obvious dearth of reading resources in bookstores and academic institutions. Even when academic resources exist, bad records management systems make them difficult to obtain. These issues arise at a time when the student population is growing, learning resources are scarce, and admittance is difficult. E-learning is a good alternative that can help to decrease, if not completely eliminate, the aforementioned hurdles that are commonly associated with traditional teaching and learning approaches.

Given the sudden shift from conventional classroom instruction in many regions of the world, some people are speculating on whether online learning acceptance will continue after the epidemic plus how this type of change may affect the worldwide school systems. Although some people think that such an unexpected and quick switch to online learning would have a negative experience for users and slow long-term development, many believe that a brand-new mixed model of instruction would evolve with a number of benefits. Lots of other people believe that the pace of digital technology's adoption for teaching and learning will pick up, and that someday, online learning will emerge as an essential component of the educational process. As a result, it is no exaggeration to suggest that the practices of e-learning will

have a big impact on how education and classroom teaching are delivered in the future.

Concept of e-learning

The word electronic learning is abbreviated as e-learning. Electronic learning, in its most literal sense, refers to any sort of learning that is aided by one or more electronic gadgets, media, or resources. The phrase e-learning has a much broader definition. E-learning in this sense, is learning that is aided through the application of electronic means, including audio and videotapes, microphones, and listening devices. Although it can be used to describe whatever form of education that is supported and made easier by the usage of technology for information and communication in broad sense, in instruction, its application is restricted as it is currently affiliated with the field of innovative educational technology, that interacts with both the innovations and associated methodologies in learning that uses intranet and or multimedia (Vidhya,2022). E-learning may make use of cutting-edge digital communication and information tools like CD-ROMs, DVDs, videoconferencing, computer-based unified communications, e-mail, web chat, Web surfing, digital reference library resources, simulations akin to video games, Web blogs, and personalized e-learning courses. Viewed from this perspective, e-learning is defined as learning that is carried out electronically and is aided and supported by the use of sophisticated learning technologies, primarily computers, intranet, and multimedia (Vidhya,2022).

E-learning is the application of online media technologies to provide a huge spectrum of information as well as performance-enhancing remedies (Rosenberg, 2013). E-learning, from this point of view, can be defined as an advanced method that employs internet services and web technologies such as e-banking, e-mail, e-commerce and e-booking to provide students with an online learning experience. E-learning encompasses all forms of electronically supported teaching and learning (Umet, 2017). It describes a computerized and virtual educational strategy wherein students could receive words, voice, photos, graphic elements, and video files simultaneously at the same time online. It is a method for interacting with digitally provided content, networked services, and tutoring assistance.

Much like words such as e-banking, e-mail, e-commerce and e-booking, the term e-learning has infiltrated the teaching and learning sector. What appears to be typical in the composition, functionality, and application of these expressions is summed up in the following:

- They all require the use of computers, laptops, and related technology in order to function.
- For them to function, they must utilize internet services and web technologies.

E-learning can be self-contained, collaborative, or facilitated. Individual learners who complete learning activities or modules at their own pace, on their own schedules, and in their own setting are referred to as independent learners. The learner is self-sufficient and avoids dealing with instructors and possibly other students. This does not imply that the student has no access to other services, such as a facilitator; instead, it is up to the student to decide whether or not to get in touch with them and, if necessary, at what point. Collaborative learning refers to online collaboration with other students while facilitated learning is designed to be completed through contact with teachers. Falana (2015) gave the examples of an email conversation with other students on a certain subject and of everyone participating in a course room or forum of educational group discussing a particular topic. On the other hand, a leaner might complete a chunk of learning online and then discuss significant concepts with instructor or classmates via email.

E-learning styles for delivering lessons

1. Assisted learning: E-learning can be used to supplement the teaching-learning processes that take place in the classroom. Thus, a student use it to learn what they need to know, for example, they can utilize multimedia, the Internet, and Web services to enrich their classroom activities and an instructor can apply it to better his instruction.

2. Blended learning: This method tries to combine conventional and Information and Communication Technology (ICT)-enhanced e-learning activities. Its activities are designed then implemented in such a way that they present a harmonious blend of traditional classroom teaching methods and e-learning-based training. As a result, one can profit from both traditional and e-learning approaches.

3. Complete e-learning: Digital classroom instruction entirely replaces regular classroom instruction in this type of education. Classrooms, schools, and teaching-learning environments do not exist as they do in traditional schooling. With the support of a well-designed e-learning course, students can finish their learning activities at their own pace. And yet, students also may have access to well-stored materials plus education packs mostly in form of taped CD-ROM, DVD, and other media. The bulk of the educational activities are conducted entirely online.

Benefits of e-learning

According to Pappas (2015), e-learning has the following benefits:

- There are other programme options: The flexibility that allows students to learn from anywhere also allows e-learning platform creators and contributors to offer and build on a wide range of programmes. Space, teacher availability, and other constraints limit brick-and-mortar learning facilities. Teachers, like students, are no longer limited by their geographical location. This gives teachers the flexibility to teach in a range of settings and capacities. This greatly broadens the range of possibilities, allowing people to learn nearly anything.
- Cost-effectiveness: In addition to being cost-effective in and of itself, e-learning allows students to work full-time while pursuing their education. This is a long way from where we were not long ago, when returning to school meant finding a part-time work or losing your employment entirely. This increases the amount of students who can enroll in courses, bringing e-learning to those who might otherwise be hesitant to continue their education. This financial gain is a gift that keeps on giving because the same students not only continue their education on a shoestring budget, but also boost their long-term earning potential by applying their newfound knowledge and accomplishment to their professional activities.
- Availability: In the past, people had to choose between quality and availability when it came to e- learning, but those days are gone. The ability to learn from anywhere has been combined with the availability of high-quality education that can be accessible from any location having Wi-Fi. Education is no longer limited by distance; rather, it is truly available to anyone who is committed to their studies. Instead than working around a school timetable, people now work around the school schedule. This same accessibility is extended to students whose first language is not the same as the teacher's. Foreign language subtitles, dubbing, and voice-overs allow people to learn from everyone, not just from a certain location.
- Flexibility: It is difficult to create a healthy work/life balance when there is a lack of flexibility in education and at work. When everyone in an individual's sphere expects him to work on their terms and on their

schedule, the quality of your work, as well as the quality of your life, suffers. E-learning gives an environment that accommodates to the flexibility that makes intelligent time management and consistent workflow a reality, from working at one's own pace to revisiting lectures and videos. Suddenly, a parent who has to learn during their child's nap or a full-time employee who needs to work evenings and weekends may both benefit from continuing their education through the e-learning format.

- Independence and time management: Online learning provides a level of flexibility that promotes strong time management and discipline while also encouraging independence. These abilities are equally as valuable as the course information and are worthwhile to pursue on their own. People frequently set objectives to improve and increase these life skills, but they are unsure how to achieve them. Fortunately, most e-learners have discovered that as a result of traveling through online courses, time management and educational independence both tend to emerge organically. Whatever the future holds, it is apparent that e-learning is here to stay. The online format's flexibility, combined with lower costs and more programme possibilities, contribute to the growth and sustainability of something that was considered sub-par only a few years ago. When one considers the programmes' diversity, life skills, and accessibility, it's no surprise that this ever-growing platform represents the future of education. E-learning has established itself as not only a feasible but also a premium educational choice, gaining a spot on the short list of educational considerations

Limitations of e-learning

- It may be a one-man show: While digital training is convenient and adaptable, it represents a one-man show. Some students may be hesitant to engage in online discussions or communicating very intensely with their digital instructors or colleagues. Additionally, for certain students to study effectively, instructor involvement is necessary. Although it can be extremely beneficial, criticism may be limiting when it is given correctly. Moreover, certain learning difficulties could be challenging to manage digitally, and several queries might get buried in an ocean of demands and questions. Students may experience a lack of confidence as well as encouragement as a result of this.
- It could be impersonal: Despite our best efforts to completely translate human relationships to digital platforms, and despite how easy it may seem for relationships to grow in front of computer systems, a virtual environment cannot be entirely human. Nothing will ever replace face-to-face interaction.
- Spending too much time in front of a computer can be harmful: The trend today is to always be online, but too much computer or tablet use can result in eye difficulties, problems with stress, injuries, and possibly other physical ailments. Your audience will cheer you on if you include instructions on the proper sitting position, workstation, altitude, plus other issues in your online class.
- It necessitates self-discipline: If a web-based learning client lacks confidence, it is unlikely that they will be motivated to study alone. While some students prefer to have their progress routinely checked in order to perform well, conventional education and training provide the advantage of promptly identifying progress and falling behind.
- It is impossible to resist cheating: E-learning, like classroom learning, includes assessment. But, there are not any instructors or invigilators there to supervise throughout

examinations. When no one is watching, it is easy for virtual learners to communicate solutions.

COVID-19-related disruptions in Nigeria education sector

The economical and educational systems of Nigeria were not crippled by previous epidemics of Lassa fever, avian flu, monkey pox, Ebola illness, and other diseases, but the Corona virus did following its outbreak in 2020. At the height of the COVID-19 pandemic in 2020, when the world seemed to come to a halt and all hope seemed to have vanished, educational institutions closed their doors to students and scholars. Concerned educational workers, aware of the potential consequences of a prolonged pandemic, look for ways to study in the middle of the crisis. As Nigeria and the rest of the world battled the COVID-19 epidemic, which interrupted educational operations around the world and showed new ways of doing things, it appears that e-learning and other educational technology were indispensable instruments that gave remote learning chances.

During the epidemic, the rising problem in Nigeria's educational sector presented a challenge to government authorities and parents. As part of efforts to preserve appropriate management of the education industry during lockdown, leaders in education rolled out a variety of technology services and tools which support remote learning and instruction and were created to match contemporary academic requirements (Adelakun, 2020). Although the size of the class was uncertain, radio systems and televisions in media houses were utilized more frequently than ever to impart knowledge to many children at once. The majority of educational technology providers also modified their platforms to support virtual education. A rise in educational websites featuring a variety of learning resources to help engage both primary and secondary school kids occurred during this time. During this time, educational technology tools underwent a redesign with features that made it simpler for parents to use them (Jegede, 2020). These developments ranged from high-tech alternatives as well as large-scale, low-tech ones (Adelakun, 2020).

Sadly, the engaged employees considered working with educational technologies in the midst of the pandemic to be a difficult assignment since the possibility of a lockdown due to a pandemic was never envisaged, let alone having appropriate preparedness to assure proper management of such developments. In truth, the majority of the innovations adopted to secure the educational sector's continued operation were copied and pasted from other countries. Higher education institutions had to remain at home more than lower levels of education during the Corona virus outbreak because there was no means to provide a supportive environment for public university institutions to switch from conventional instruction to remote learning.

The brief shutdown of schools encouraged parents to become more actively involved in their children's education on a higher and much more technical level because their children were present and they could understand their academic capacity in detail. Several parents found this challenging because they bore personal responsibility for the academic success of their school-age children. On the other side, some parents found it intriguing to determine the roles of teachers and make sure they transfer valuable knowledge to their kids, who were still relatively new to educational technologies. This made it easier for parents who could afford it to teach their kids how to be contributing, respectable society members (Babatunde, 2020). Children whose parents could not afford e-learning resources had a different experience, as they stayed idle throughout the Covid-19 pandemic-related

school closures. This affected all academic programmes including business education.

The goal of business education is to prepare students for careers as employees, business owners, managers, or self-employed people (Anao, 1986). Business education specifically attempts to produce people who are well-equipped with competences to support anyone in seeking a job, whether it is through starting a new firm or being hired and putting their abilities to use (Uko-Aviomoh and Ajuluchi, 2008). According to Osuala, two components of the business education educational curriculum are office education and general business (2004). A general business education curriculum provides participants with the knowledge and skills needed to run their own businesses and reap the benefits of the corporate world. Workplace education is a course that prepares students for a job in today's office.

Through an academic framework that provides not only marketable skills, as technical and vocational education currently does use conventional instructional approach, and also higher - level thinking, problem-solving abilities, as well as collaborative expertise, workers must all be primed for entry into and progress in the place of work of the next century (Doolittle and Camp, 1999). According to the National Policy on Education (2013), the goal of business education will be achieved by students becoming able to interact and collaborate with other learners all over the globe via online learning and evaluating worldwide library functions from wherever they may be. The traditional method of instruction does seem to be missing the mark of this goal in the twenty-first century (Hanley, 1995). In the age of information, communication, and globalization, the challenge of successfully structuring the class to reach the admirable goals of business education utilizing the conventional means of instruction is now a key problem both to students and instructors in the course. The change rate driven about by technological innovation, according to Kwache (2007), has significantly altered how individuals lead, work, and enjoy all across the globe, and business education is no different. For this reason, the traditional approaches to instruction plus studying in addition to the manner in which education is run are under danger from evolving plus new innovations. Business education is not immune to the global paradigm change from traditional teacher-centered education towards contemporary methods that incorporate e-learning.

Ways of promoting e-learning in business education beyond the Covid-19 Pandemic

The methods for promoting e-learning in Business Education in our academic institutions are as follows.

1. The first and most important thing to accomplish is to cultivate a favorable attitude toward e-learning procedures and products. For this reason, serious efforts should be made to create a society that value e-learning as highly as conventional, in-person learning. The benefits of e-learning should be made clear to the recipient of Business Education. In any event, they must not be given the impression that digital learning is less effective.
2. Create the infrastructure needed for educating as well as preparing business education students, instructors, and support personnel in the fundamental technical know-how and abilities related to the use and operation of communication systems, computer systems, and their connectivity, with an emphasis on the Web and Internet technology.
3. Ensure that staff and students receive the appropriate training, not only to prepare them technologically to engage in e-learning but also to ensure that they completely

comprehend all possible benefits gained from such initiatives. The following actions could be made in this regard:

i. Business education students may be guided to online resources for their course work, basic knowledge, character building, creativity improvement, and enhancement of their special interests and abilities.
ii. Introduce students to individual sites that offer benchmark resources and tools such as multilingual dictionaries, grammar and spelling tools, maps and globe atlases, encyclopedias, and historical, geographical, scientific, and cultural milestones in human progress.
iii. Introduce business educators and support staff to websites that offer classroom management tools, such as software for creating on-line or paper tests, explaining the technique of grading or classification or even performing these tasks independently, problems and questions for classroom drill, practice, and recapitulation work, diagnostic testing and remedial measures.
iv. Introduce faculty, staff, and students to websites that offer standard academic resources, such as worksheet generators for involving students in activities like specific crosswords, dictionary lookups, obfuscation techniques, arithmetical workouts, fractal geometry and sketch practice, as well as interactive media study guides.
v. Make internet access and websites for the classroom available to business educators and their students so they can use e-learning to carry out classroom tasks. An institution can use its website to provide appropriate support or additional services to traditional classroom instruction and school activities, or it can construct a successful on-line learning program that can serve as a substitute for live classroom instruction.

Conclusion

The word electronic learning is abbreviated as e-learning. It can be thought of as a type of ICT that is utilized to provide students with online learning experiences via the application of internet services plus computer web technologies. However, in today's world, the word e-learning refers to more than just the use of the Internet and Web technology. As a result, modern e-learning can be defined as learning that is carried out, supported, and assisted by cutting-edge multimedia facilities, in addition to Web-based and Internet-based technologies, and supplied to target consumers via relevant ICT devices, E-learning is said to have some significant downsides, that users face, including but not limited to difficulty in getting sufficient access to the application of interactive media, world wide web, as well as digital world, teacher resistance to or difficulty in making it available to students, and a feeling of loneliness felt by users. Inspite of the limitations associated with e-learning, e-learning may benefit learners in a variety of ways, including providing personalized learning tailored to each student's needs, capabilities, studying preferences, and aspirations, providing direct connection to an infinite variety of learners with the same threshold of information as a full-time pupil, and encouraging collaboration among students from various locations and cultures. In order to promote and arrange for e-learning in Business Education in our schools and universities, a variety of measures could be used, such as cultivating a positive mindset towards the e-learning processes and outcomes, supplying the necessary equipment for instructing students, as well as supporting staff, in the use and operation of interactive media devices, computer systems, plus their network technology, and raising full awareness about all.

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ASSESSMENT OF ANTIBIOTIC USE IN BROILER MANAGEMENT: UNNOTICED EFFECTS AND ALTERNATIVE STRATEGIES FOR SUSTAINABLE POULTRY FARMING – A REVIEW

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Abstract: *Antibiotics are incorporated in broilers' feeds in order to prevent and control diseases as well as improving feed efficiency and boosting immune system. However, misuse, overuse and abuse of antibiotics in broiler production has led to the emergence of antibiotic multidrug resistant pathogens and antibiotic residues in broiler meat. Ipso facto, this unfortunate developments require the actions of certain regulatory Organizations as Food and Agricultural Organization (FAO), World Health Organization (WHO), United States Department of Agriculture (USDA) and European Union (EU) to ban the continuous use of antibiotics in broiler production worldwide while emphasis has now been placed on safe, cheap and readily available alternatives to antibiotics to be adopted by broiler farmers as well as promoting sound human health and friendly ecosystems. Therefore, the highlights of this review paper centres on: Assessment of Antibiotic use in broiler, effects and alternative strategies for sustainable poultry farming.*

Keywords: Antibiotics, Broiler, Economic impacts, Alternatives, Sustainable Farming
Citation:
Eko, P. M., Ekpo, U. E., Afolabi, K. D. and Idio, A. D.(2023). Assessment of Antibiotic Use in Broiler Management: Unnoticed Effects and Alternative Strategies for Sustainable Poultry Farming – A Review. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 632-640

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Introduction

Broiler rearing has tremendous economic potentials worldwide and it has become an organized, specialized and integrated industry. Broiler chickens have the efficiency of converting grains and other agro-industrial by-products into quality meat that is the cheapest source of protein and probably the most consumed. Broilers are reared particularly for their soft tendered, less cholesterol meat broilers. Meat qualities (such as appearance), water holding capacity, texture and composition have all contributed to consumers' acceptance across different cultural backgrounds and are devoid of taboos associated with other breeds of animals (Sanwo *et al.,* 2012). In addition, broiler chickens has unique features of fast growth rate, high carcass yield, short cycle of production, ease of management and small space requirement (Eko *et al.,* 2020).

Their adaptability to intensive management system and large-scale production has

accounted for the rapid and incomparable growth of the industry globally in terms of reasonable financial turnover and sustainability annually (Bello *et al.,* 2017). The intensive management system, being a practice of raising animals in a confined environment; moreso, involving large-scale with concomitant incidence of overcrowding and rapid disease to transmission among flocks or herds, requires unavoidable use of antibiotics either as prophylactic, metaphylactic or therapeutic for prevention of morbidity, mortality and growth promotion. Antibiotics are also used to improve feed conversion ratio (FCR), reduce toxin formation and increase weight gain (Akinwumi *et al.*, 2012 and Adeoye *et al.*, 2016).

Studies have reported that unnecessary use, over and under prescription, wrong combinations, lack of accessible veterinary services and high charges, distant locations, free access to antibiotics, farmers' high motive drive and little background knowledge on antibiotic application are some of the factors that encourage abusive use of antibiotics by local broiler farmers which are responsible for dangerous trends of antibiotic resistant microorganisms and antibiotic residues in broiler meat. Therefore, given these serious public health implications arising from antibiotic use, new approaches should be adopted for safer broiler production and consumption, thus the current review seeks to highlight as follows:

- Brief historical perspectives on the use of antibiotics in animals vis-à-vis broiler production.
- Development of Antibiotic Resistant (AR) Microorganisms.
- The process of Antibiotic Residues in broilers meat
- The Mechanism of Resistance
- The Economic Impacts of Antibiotic use
- Alternative Strategies to Antibiotic Use in Broiler Production.

Brief Historical Perspectives on the Use of Antibiotics in Broiler Production

Antibiotic use in animal production dated back to 1910 when shortage of meat products prompted workers to protest across America (Ogle, 2013). In an attempt to produce meat at relatively cheaper cost, some scientists at that time started making use of antibiotic and other antimicrobials agents for non-therapeutic purposes of growth and prevention of infections. The actual use of antibiotics in poultry began in 1950 when Stokstad and Jakes added residues of Chlortetracycline production to chicken feeds with the objective to serve as a source of vitamin B12 but it caused a growth stimulation that was far too large to be explained as a vitamin effect (Falcao-e-Cuhn *et al*., 2009). This observation was quickly extended to other antibiotics and animal species, thus leading to widespread adoption and utilization of antibiotics in animal nutrition. Poultry especially broiler production is the commonly farmed species with over 9-billion tons of meat produced by year (FAO, 2017). Despite its ban, a large diversity of antibiotics produced are used to raise broilers in most countries (Agyare *et al.*, 2018).

Development of Antibiotic Resistant (AR) Microorganisms

Of recent times, antibiotic resistant (AR) has become a buzzword within medical veterinary and public health practitioners. Antibiotic Resistance is not a new phenomenon since all microorganisms have an inherent capacity to resist some antibiotics but has become an issue of global interest (Aarestrup *et al.*, 2008). Within the context of this review, antibiotic resistance is defined as the ability of an organism to resist the killing effects of antibiotics to which it was normally susceptible (Agyare *et al.*, 2018). From diverse studies and observations, administration of antibiotics affects both targeted pathogenic organisms and non-targeted commensals, hence frequent antibiotic use creates a pool of resistant commensal bacteria that contribute to

the general increase and dissemination of bacterial resistance worldwide and can be a source of resistant genes for pathogens. This possess a great risk for human pathogens since the same antibiotics are also used for humans and animals (Olufemi *et al.,* 2015).

The Process of Antibiotic Residues in Broiler Meat

As already highlighted on the previous pages, frequent and misuse of antibiotics in broiler production has not only produced antibiotic multidrug resistant strains but also results in the presence of residues in edible tissues intended for human consumption. Satter *et al.*, (2014) reported antibiotic residues accumulation in liver, kidney, thigh meat, gizzard and muscles. According to Akinwumi *et al.*, (2012), antibiotic substances, upon application, get stored in various parts and tissues of the broiler, thus resulting in antibiotic residue for consumers if proper withdrawal period is not adopted before slaughtering.

Since most antibiotics that could lead to residue problem are associated with treatment of health issues, intramuscular and subcutaneous routes of administration are considered the most route associated with antibiotic residue in food animals followed by oral administration. In order to reduce the harmful effects of residues on consumers, FAO, WHO and EU jointly established the Maximum Residual Limits (MRL) for veterinary drugs in approved guidelines of Codex Alimentaruis (Ezenduka *et al.*, 2016). In a study reported by Ezenduka *et al.* (2016), MRL of tetracycline for some organs were indicated as 0.2ng/kg for muscle, 0.6ng/kg for liver and 1.2ng/kg for kidney. Ronquillo and Hemandez (2017) also reported on the MRL for antimicrobial residues in poultry products applicable to EU Nations indicated in Table

Table 1: Maximum Residue Limits (MRL) for Antimicrobials Residues in Poultry Products Applied in European Union (EU)

Substance	Chemical group	Matrix	MRL, mg/kg
Tetracycline	Tetracylines	Muscle	100
		Liver	300
		Kidney	600
		Egg	200
Streptomycin	Aminoglycosides	Muscle	600
		Fat	600
		Liver	600
		Kidney	1,000
Tilmicosin	Macrolides	Muscle	150
		Liver	2,400
		Kidney	600
		Skin and fat	250
Florfenicol	Amphenicols	Muscle	100
		Skin and fat	20
		Liver	2,500
		Kidney	750
Tiamulin	Pleuromutilins	Muscle	100
		Liver	1,000
		Skin and fat	100
		Eggs	1,000

Source: Ronquillo and Hemandez, (2017)

According to Plumb (2008), two (2) basic methods can be used to quantify the concentration of anti-microbial residues in foods: Chromatographic and Immunochemical methods. While Chromatographic method is quantitative and specific. Immunochemical method entails both quantitative and qualitative aspects; an example is ELISA (Enzyme Linked Immunosorbent Assay). Both methods are used to confirm screened samples that are positive and also determine the concentrations of the incriminated antimicrobials.

Mechanism of Resistance

Bacteria counteract the actions of antibiotics by four (4) mechanisms, namely: Enzyme modification, alteration in target binding sites, efflux activity and decreased permeability to bacterial membrane (Bassetti *et al.*, 2013). This expression of resistance towards antibiotics by bacteria could be intrinsic or acquired. Generally, when an antibiotic is used in any setting, it eliminates the susceptible bacterial strains leaving behind those with traits that can resist the drug. These resistant bacteria then multiple and become the dominant population. They are then able to transfer the genes responsible for resistance to other bacteria (Laximinaraya *et al.*, 2013). Olufemi *et al.*, (2015) further reported that most resistant bacteria have mobile genetic elements such as R-plasmids and transposons that can carry the resistant genes to some pathogenic strains of bacteria such as *Salmonella, Shigella* and *Escherichia* which are resistant to resistant to ampicillin, streptomycin, chloramphenicol, tetracycline and amoxicillin etc.

Unnoticed Effects of Antibiotic Application

The extensive and uncontrolled use of antibiotics for growth promotion and disease prevention in broiler production has led to increased antibiotic multidrug resistance and residues, (Nisha, 2008), with further multifaceted negative effects on broilers' health status, consumers' health, meat product and the environment as concisely explained below.

Effect on Chicken's Growth, Digestive Tract and Immune System

The broiler industry uses antibiotics to improve meat production through increased feed conversion, growth rate and disease prevention. Antibiotics can be used successfully at sub-therapeutic doses in broiler production to promote growth and to protect the health of the birds by synergistic effect on the immune status (Lee *et al*., 2012). These positive effects are mainly due to the control of gastrointestinal infection and microbiota modification (Singh *et al.,* 2013). For instance, the use of Virginiamycin (100ppm) as growth promoter has been associated with increased abundance of Lactobacillus species in broiler's duodenal loop at proximal end, imphying that Virginiamycin alters the composition of broiler gut microbiota (Lin *et al.*, 2013). A change in the intestinal microbiota of broiler chicken can influence their growth, immunity and health. According to Lee *et al.* (2012), changes in the intestinal microbiota of broiler chickens are influenced by factors such as housing condition, exposure to pathogens, diet composition and the presence of antibiotics in feeds.

Effect on Meat Quality

The most common type of *E. coli* infection that causes meat poisoning in *E. coli* 0157:H7 and Salmonella spp is one of the most common meat borne infection, which often results in gastroenteritis (Mehdi *et al.*, 2018). According to a review by Mehdi et al (2018), broiler meat contamination rate for *E. coli, Campylobacter* and *Salmonella* spp are respectively 96%, 25% and 34% in Canada. In addition, antibiogram test revealed multidrug resistance in *Enterobacteria* isolates from broiler meat (Yulistians *et al.*, 2017). This contamination is due mainly to proliferation of antibiotic resistant pathogens in the intestine.

Effect on Consumer Health

Several antibiotic residues of penicillin, tetracycline, aminoglycoside and amphenicol have been detected in broiler meat (Diarra and Malouin, 2014). Residues in broiler meat can have adverse effects on humans. One of the most concerning problems associated with tetracycline is idiosyncratic reactions especially in hypersensitive consumer (Ezenduka *et al.,* 2016) Tetracycline residues in meat potentially may stain teeth of young children (Kummerer 2009). There is also a case of Clenbuterol (a beta-agonist) used by broiler farmers to produce

fatless meat being implicated in muscle tremors, palpitation and tachycardia. According to Laximinarayan *et al*., (2014) and Adeoye *et al.,* (2018), consumers are concerned with antibiotic residues in broiler meat which may be the cause of numerous health challenges ranging from toxic effects of antibiotic multidrug resistant bacteria which may be transferred from meat to humans, immunopathological effect and carcinogenicity (related to sulphamethazine, oxytetracyline, furazolidone), mutagenicity and nephropathy (gentamicin), hepatotoxicity, reproductive disorders, bone marrow toxicity (chloramphenicol) and allergy (penicillin). The incidence of antibiotic residues in broiler meat becomes compounded with intrinsic factors as pesticide residues, synthetic feed additives, colouring and flavouring agents, and genetically modified organisms (GMOs) utilized in ration formulation (Hague *et al*., 2020).

Effect on the Environment

According to Manzetti *et al.*, (2014), the most vulnerable ecosystems to antibiotic contamination are confined aquatic environments such as ponds, lakes and soils in urban sites. These can play an important role in evolution, transfer and ecology of antibiotic resistant genes (Marti *et al.*, 2014). After metabolic changes in broilers, 30% to 90% of the antibiotic administered are excreted into the environment via wine, faeces and bedding materials (Carvalho and Santos, 2016). This makes sewage disposal systems one of the most important routes by which antibiotics can enter into the environment (Ronquillo and Hemandez, 2017). According to Pan and Chu (2017), antibiotics leaching is higher in sandy soils than in clay and salty soils. Norfloxacin and tetracycline tends to persist in the soil surface while sulphamethazine and erythromycin pose a higher risk for deeper soil layers and ground waters. Litter or animal bedding materials containing residues of bactracin, penicillin, salinomycin and virginiamycin can also contaminate the soil. Carvalho and Santos (2016) reported that antibiotic-by products in the environment have the potential to remain bioactive, toxic, stable and mobile than their parent compounds.

Alternative Strategies to Antibiotics in Broiler Production

The growing criticisms and ban on antibiotics in animal production seriously necessitates the search and development of alternative substances that are cheap, readily available and safer to animals and humans. There are a number of non-therapeutic alternatives to antibiotics. These include: probiotics and prebiotics, organic acids, amino acids and enzymes and phytogenic feed additives (Shehu *et al.*, 2012).

Probiotics and Prebiotics

The term probiotic, meaning "for life" is a Greek word. Several authors have given different opinions on developmental perspectives and benefits of probiotics. As defined by R. B. Parker in 1974, probiotic is a live microbial feed supplement which beneficially affect the host animal by improving its intestinal microbial balance (Schrezenmeir and DeVrese, 2001). Probiotics can replace antibiotics by changing the intestinal microbiomes, thereby producing some effects of antibiotics. For instance, feed supplementation with probiotics for broilers improves the feed conversion ratio (FCR), intestinal health and faster growth by reducing the intestinal pH, altering bacterial composition as well as improving digestive activity (Ghasemi *et al.*, 2014).

Probiotics also stimulates endogenous enzyme systems to reduce the production of toxic substances by bacteria while enhancing the synthesis of vitamins and antimicrobials such as bacteriocins (Pan and Yu, 2014). Probiotics also improves the meat quality of broilers by positively affecting the protein and fat contents, with effects on water holding capacity, colour

(appearance), pH, oxidation stability and composition (Pan and Yu, 2014). The administration of *Enterococcus faeciun*, *Streptomyces spp*, and *Bacillus spp* in broilers' feed triggers antibacterial effects on pathogenic bacteria in the small intestine. In addition, probiotics possess cocidiostatic effect on *Eimeria tenella* strains and reduces the spread and risk of Coccidiosis in broiler production thus maintaining intestinal health (Mehdi *et al.*, 2018).

Since the concept and purpose of probiotics is to re-establish the ideal balance between the beneficial and pathogenic microorganisms in the gut, most microorganisms used are strains of Gram-positive bacteria of the genera: Bacillus *(B. Cereus, B. licheniformis, B. subtilis); Enterococcus (E. faecium); Lactobacillus (L. acidophilus); Pedicoccus (P. acidilactici)* and *Streptococcus (S. infantarius)* (Shehu et al, 2012). Certains strains of yeasts and fungi are also used especially *Saccharomyces (S. cerevisiae).* Yeasts are believed to be a source of B. vitamins, proteins and trace minerals (Shehu *et al.*, 2012). Robinson and Erasmus (2009) also reported that yeast may directly improve gut environment by creating favourable pH, supplying micronutrients and scavenging of oxygen, all which are necessary for the growth of cellulolytic bacteria, hence promoting increased feed intake, nutrient utilization and growth performance in broilers.

Prebiotics, on the other hand, are the non-digestible components of feed that exert potential beneficial effects on the health. Most prebiotics are fermentation products consisting of oligosaccharides and short chain polysaccharides (Baurhoo *et al.*, 2007). Baurhoo *et al.* (2017) reported that the inclusion of 0.2% mannan oligosaccharide in the chicken diet tremendously improved the intestinal health more than antibiotics thereby reducing harmful bacteria and increasing the beneficial ones. Nevertheless, the combination of both probiotics and prebiotics has resulted in synbiotics, with more efficiency of maintaining favourable intestinal health through prevention of infection and increased nutrition utilization.

Organic Acids

Organic acids are preservative agents widely used to prevent feeds from microbial spoilage and to improve nutrient digestibility (Kum *et al.*, 2010). Several organic acids are available but the most frequently used are acetic, formic, butyric, propionic and citric acids. Although weak acids in reactions and safer for consumers, organic acids can inhibit the microbial growth by disrupting bacterial enzymatic reactions and decreasing the transport of acidic compounds by non-ionic diffusion through the cell membrane (Hassan *et al.,* 2010). The antibacterial effect of dietary organic acids in broiler is believed to take place in upper parts of the digestive tracts (crop and gizzard) (Hinton *et al.*, 2000). In a number of broiler production studies, it has been reported that the inclusion of organic acids in feed may improve the growth feed conversion rate and feed utilization as well as having the potentials to inhibit *E. coli* infections (Mohammadagheri *et al.,* 2016). Richel *et al.,* (2020) reported that formic alone or in combination with propionic acid at the rate of 0.6% can inhibit *Salmonella* and *E. coli* infections and other food borne pathogens.

Amino Acids and Enzymes

Broiler feeds supplemented with amino acids and enzymes can enhance the digestibility of feed through the degradation of proteins, phytates and glucan, thereby increasing feed conversion (Mehdi *et al.,* 2018). Also, the antibacterial efficacy of several lysins has been reported; for instance, peptidases, amidases and lysozymes showed antimicrobial potential against *Clostridium perfringens* in poultry (Rios *et al.,* 2016). Lysins are bacteriophagic endolysins that are alternative therapeutic option to antibiotics.

Phytobiotic Feed Additives

Phytogenic Feed Additive (PFAs) also known as phytobiotics or botanicals are derived from plants-herbs, shrubs, spices – and their utilizable parts (leaves, barks, roots, extracts and essential oils). PFAs are reported to positively affect growth in broilers by improving feed conversion ratio (FCR), boosting the immune system, regulation of intestinal microflora and stress reduction (Ojebiyi *et al*, 2016). Apart from their bacteriostatic and bactericidal activities as observed in garlic, ginger, turmeric, neem etc, many PFAs are also sources of minerals, vitamins and phytosterols which are responsible for positive physico-chemical effects in broilers.

A study reported by Mpofu *et al* (2016) on *Lippi javanica* leaf extract in broilers showed its potential to stimulate glycolysis with increased energy production as well as action on fatty acid profile, thus promoting growth performance. It has also been reported that the use of garlic extract at 5g/kg in broiler feed enhanced feed intake and weight gain as garlic can stimulate the secretion of intestinal enzymes responsible for protein digestion and absorption (Kirubakaran *et al,* 2016). PFAs are also sources of essential oils such as gingerol, zingerone, eugenol, thymol and turmerone etc. These essentials oils have wide and proven pharmacological activities against myriad of microorganisms by interfering with their enzymatic systems and modulating their inflammations and immune responses (Khattar *et al.*, 2014)

Conclusion and Recommendation

The twin challenges arising from the antibiotic multidrug resistance and residues in broiler meat are indications of their harmful effects on public health. It is thus, necessary for broiler farmers to adopt safer and cheaper alternatives to antibiotic use for their sustainable broilers production vis-a-viz performance optimization and minimization of economic losses since broiler farming still remains the most vibrant aspect of poultry subsector for quick returns and supplies of quality animal protein.

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Child Labour And Cultural Belief In Uyo Metropolis: The Anthropological Perspectives

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Abstract: *This paper is an Anthropological interrogation of roles of cultural belief in modern day child labour in Uyo metropolis, Akwa Ibom State. The researchers made use of absolute deprivation theory as a framework. Survey research design was used in this study by the researchers. A multiple sampling technique involving probability and snowball sampling were used to select study participants for interview within the streets of Uyo metropolis. Fatterman big-net approach was used as an ethnographic sampling technique. Primary data were collected through personal in-depth interviews, key informant interview, observation and informal discussion. Findings of the study were analyzed qualitatively thematically with excerpts (verbatim reports) from emic responses of the people. Findings of the study revealed that factors like parents' influence, inherited cultural practice and culture of investment otherwise known as "Akudadu-ubok", play key roles in promoting the practices of street hawking in Uyo metropolis as a great form of modern-day child slavery. It was recommended that Government should ban street hawking by children as form of investment by parents and guardians. Also, the cultural ideology of "Akudadu-ubok" should be abolished among Akwa Ibom people in order to raise a sense of responsibility among parents across Akwa Ibom State.*

Keywords: Cultural belief, child labour, akudadu-ubok

CITATION:
Peters, M. I. and Bassey, A. E.(2023). Child Labour and Cultural Belief in Uyo Metropolis: The Anthropological Perspectives. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 614-621

Introduction

Child labour is not only a memory of the past, but also a cruel reality of modern times that affects the most vulnerable members of our society and precludes them from a life of freedom and dignity (United Nation, 2016). The passing of the Slave Trade Act on 25 March, 1807, led to the eventual abolition of transatlantic slavery. The Act has been hailed as an international victory for humanity. Yet, while the world celebrates its anniversary, there are still millions of children currently held as slaves, forced to work long hours for no or little pay and left vulnerable to extreme harm, violence and rape (Save the Children, 2007).If slavery is so morally deplorable that it has been outlawed in every country and in international agreements again and again, why are there millions of enslaved people today? Why are children so often the victims? Why are children and youths being used as disposable resources in agriculture, manufacturing, sports, domestic service, combat, the sex industry, and illicit activities? (Upchurch, 2002).Despite the fact that many people believe that slavery no longer exists, the International Labour Organization (ILO, cited in Amnesty International, 2017) estimated that there are some 5.5 million children in slavery across the world. Modern day slavery takes many forms which include: forced labour, sexual slavery, child labour, bonded labour, forced marriage, and descent-based slavery (Amnesty International, 2017).One of the disturbing forms of modern-day slavery is child labour. An estimated 246 million children are engaged in child labour. Nearly 70% (171 million) of these

children work in hazardous conditions – including working in mines, working with chemicals and pesticides in agriculture or with dangerous machinery. They are everywhere, but invisible, toiling as domestic servants in homes, labouring behind the walls of workshops. Children are trafficked (1.2 million), forced into debt bondage or other forms of slavery (5.7 million), forced into prostitution and/or pornography (1.8 million) or recruited as child soldiers in armed conflict (300,000) (UNICEF, 2016).

Children are especially susceptible to becoming victims of modern slavery, including domestic servitude, sexual exploitation, forced child begging, trafficking, early marriage, forced recruitment of child soldiers, and employment in hazardous conditions (United Nation, 2016).Child labour is a problem we all either know much of or have heard much about and many are daily working on it; while some are trying to help eradicate this social menace, others are making money (directly or indirectly) from it (Osita-Oleribe, 2006).Child labour as a form of slavery has been a visible characteristic in the Nigerian society. Child labour which is hazardous to the physical, mental, spiritual, moral, or social development of children in Nigeria can interfere with their education (Okeshola and Adenugba, 2018). Child labour is infringement to human rights of the Nigerian children who are expected to acquire free and compulsory primary education at the expense of various Federal/State Governments in Nigeria (Ajagun, 2012). The number of child labour is increasing in Nigeria, and about 15 million children in Nigeria engaged in child labour (Adegun, 2013; Ajakaye, 2013).

Child labour is a serious problem and a challenge for many developing countries especially in Nigeria. It affects the future generation of the nation, as these children are psychologically affected due to the kind of work, condition of work, and working environment they found themselves (Brown*et al.*, 2002). The type or qualities of work amounts to child labour if it is exploitative and/or injurious to any aspect of the developing personality of the child, and the impact of child labour on a child varies from work to work. Child labour is a form of slavery in which a child work under such situation/s that are dehumanized to him/her and generate a sense of loss of right and self-dignity (Nwazuoke and Igwe, 2016). Children are exposed to hazardous health condition in child labour, a situation that is similar to the Atlantic slave trade conditions which many Africans were transported to Europe and America under hazardous health condition through which thousands of them couldn't make the journey to the end.

Today children in Nigeria are forced to work in similar conditions, and are treated as slaves in their working conditions. These children are vulnerable to diseases and they struggle with long-term physical and psychological pain (Osment, 2014). Many children are exposed to long hours of work in dangerous and unhealthy environments, carrying too much responsibility for their age. The fact that these children are working in these hazardous conditions with little food, small pay, no education and no medical care, establishing a cycle of child rights violations (UNICEF, 2006).

Many children today are forced to work at the age that they are supposed to be taken care of by their parents, guardians and be protected by the government. A lot of children all over the Nigeria have become medium of wealth generation for some people, organizations, parents, and relatives. Modern slavery has really affected the children today because a lot of attention by the government and other agencies has been shifted from protecting the rights of the children to war against importation and transportation of drugs, oil bunkering, corruption, and other political issues because there are more gains from these areas as

compared to the fight against violation and abuse of children. Modern day slavery is consuming the children because in some ways the concerned parties are not aware of this new form of slavery. It takes forms in which it is not discovered to be slavery as compare to generally known Atlantic slavery. This might be because it is rooted in the culture of the people.

There are many factors that are responsible for modern day child slavery. According to Fawole, Jacob and Osunggbade (2003), factors include poverty, high cost of living, lack of sponsorship, poor school performance, single parenthood, large family size, peer group pressure, poor home conditions, lack of parental care, parents" unemployment, parental pressure, poor scholastic achievements. In some cases, children get involve in child labour to help their parents or families in times of financial distress by paying for some or all of the family's rent, food, clothes, utilities and so on (Ekpenyong and Sibiri, 2011). Parents/guardians have been using their wards/children. According to Hosen (2010), in Bangladesh poor rural parents can barely afford food let alone pay for school fees for their children. According to Aqil (2012), when parents have worked in their childhood their children will work as well, passing it from generation to a generation. As a result, once they are grown, they become uneducated and low-skilled. Therefore, parents' education plays a vital role in children education as it can increase the possibility for their children to have a good education (Aqil, 2012; Wahba, 2000).

The impact of this slavery is influencing every aspect of the Nigerian society. From family life, religion, business to governance and the most affected class of Nigerians in this social menace has always been the innocent children who cannot defend their rights. Many children serve as slaves in many homes in Nigeria. Some of them are used as house maids and are maltreated by guardians. In the religious circle, a lot of children are treated as slaves by prophets, parents and guardians on the premise of being possessed by evil spirits to cause misfortune for their families and that of their guardians. In business, many children are found across the streets of Nigerian towns and citiesas hawkers that work under dangerous condition. The government at different levels have accepted the United Nation Children Right, and made laws/Acts to protect these children. The challenge remains that these laws/Acts are abused every day on the streets, schools, churches/mosque, and homes without the serious intervention of the government agencies to prosecute those who perpetuate modern day slavery with children.

In this dispensation of world advocacy for Human Rights, Human Freedom, Democracy, and global liberty, child slavery is perpetuated by people through subjecting children to hard and forced labour. Forced labour takes away the right of a child as was perpetuated by the Europeans during the Cross-Atlantic slave trade. Forced labour is one major characteristic of slavery. The slavery nature of child labour is what is calling for concerns from all relevant parties. This is because the rights of children are violated everyday on the streets, homes, industries, and schools. Children are abused and used by adults for selfish purposes and earnings.

Today in Akwa Ibom State, many children are under forced labour. They are found on the streets of Uyo metropolis and other parts of the state working like slaves, hawking on the streets, not for their welfare alone, but for their parents, guardians and masters who bought them for certain amount of money for a certain period of time. In Akwa Ibom State, the child right Act which was adopted and signed into law are abused day in day out especially on the streets and different homes within the state. These children are facing hazardous working conditions every day, and most of them work for long hours despite their health conditions. UNICEF (2006)

reported that many children are exposed to long hours of work in dangerous and unhealthy environments. Literature like Amnesty International (2017), UNICEF (2016), Ajagun (2012), Adegun (2013), Ajakaye (2013), and others have written on street hawking as a form of child abuse and child labour, but have not been considered as a slave labour which is the major focus of this study. On this back-drop, this research work sought to examine the roles of cultural belief in the perpetuation of child modern day slavery in Akwa Ibom State as investigated within Uyo metropolis.

Theoretical Framework

Absolute Deprivation Theory

Absolute deprivation is generally defined as encompassing a minimal level of need rendering a person able to subsist and to participate actively in society (Wiley, 2014). According to Wiley,in practice, absolute deprivation is often synonymous with absolute poverty, defined as the absence of the minimal resources to afford the basic necessities for life. These basic needs usually refer to a minimal standard of a set of goods, which often include food, clean water, clothing, sanitation facilities, shelter, education, information, and health care. This broader definition of absolute deprivation or absolute poverty reflects an expanded notion of minimal living standards. This conception of poverty grew out of a more traditional definition of poverty, meaning income insufficient to obtain the minimum necessities for the maintenance of physical survival. These absolute measures of poverty are important in estimating the effect of disadvantage, often measured by prevalence or average intensity of poverty, on an array of population-level outcomes, including health, well-being, productivity, and social cohesion, as well as individual-level measures of health, productivity, and well-being (Wiley, 2014). Shows a state of deprivation which the children go through as they undergo forced labour, rights violations, abuse, criminal tendencies and exposure to bad health conditions. The risk of death by accident and other factors is high especially for the street hawkers found along the streets of Uyo metropolis of Akwa Ibom State, Nigeria.

Methodology

Survey research design was adopted because it expedites the search for information to acquire proper understanding about a fact or social problem. This was achieved through the employment of explanatory potentials of the survey design which make qualitative research possible and easy. The study was conducted in Uyo metropolis, Uyo Local Government Area of Akwa Ibom State. Uyo metropolis is considered as the centre of Akwa Ibom State capital. Uyo metropolis occupies Uyo Local Government Area, parts of Itu Local Government Area, Uruan Local Government Area, Nsit Ibom Local Government Area, Ibesikpo-Asutan Local Government Area and Etinan Local Government Area. It is a much-organized city with beautiful structures and a highly diluted population. The city center is known as Plaza and it connects all the major roads in Uyo; Aka Road, Abak Road, IkotEkpene Road, Barracks Road, Nwaniba Road and Oron Road.

According to Akwa Ibom State Demographic Profile (2018), Uyo Local Government Area has a projected population as calculated based on the 2006 census result indices to stand at 456, 996 of both males and females. Since the study was qualitative research with the aim of seeking information from the targeted population, no calculated sample size was needed. The researchers adopted a big-net approach (Fatterman, 2010) to determine sample size after deciding on what and who to study. The researchers use probability sampling technique with snowballing to select study participants who were found to be parents of the teenage hawkers, road side traders, hawkers from 15 years of age and above. Primary data were collected through personal in-depth interviews,

key informant interview, observation and informal discussion. Interview schedule was adopted as the research instrument for this study. This was because interview schedule is the best study tool for ethnography study and qualitative research design. The interview schedule was structured with opened questions which allowed the respondents to give information without being limited to specific response. Uyo metropolis was segmented into the major roads which were Abak Road, Ikot Ekpene Road, Aka Road, Oron Road, Calabar-Itu Road, and the Ibom Plaza. Participants were engaged within 20 to 60 minutes of interview and discussions were necessary.

Results

Culture of investment and Child Labour

Emerging from interviews is the fact that slavery which involves child labour has been part of Akwa Ibom people of the Niger Delta region right from the pre-colonial era. Having the children take care of their parents from childhood days has been part of the way the people in this part of the world. Most of the study participants agreed that cultural practices have great influence over modern day child slavery especially, in street hawking, and house maids. The challenge faced by the fight against child slavery in form of child trafficking in Akwa Ibom State is due to the weight of cultural influence over child labour among the people of the state. Narratives from study respondents show that child labour is culturally rooted among the people, and the children are seen as products for investment and profitable economic purposes.

One of the key informants aged 50 years in his narratives said that:

> *We have lived with this thing over the generations. Our people believe that child should take care of parents. That is why we have kings and queens who believe that they* should be served instead of them serving the people. The history of child labour can be traced to our forefathers who used to acquire many wives in order to have many children who will cultivate their farm lands and tap their palm wine in order to make him a rich man in the community. These things are what you are seeing today and because it is in our blood, the government efforts seem not to be working because it is part of our lives (Ken 50, interviewed on 9/7/2019).

Another key informant aged 64years in her narratives reported that:

> You will find it difficult to find out why our people practice housemaid and other forms of child labour. This is because our elders, our fathers used to have maids. Maids were slaves, those whose parents will send to go and serve another person; his friend or relatives for some fortunes. Some parents used to sell their own children those days for good fortune. This land call Akwa Ibom State has slaves who have become part of different communities and villages. These slaves have taken leadership positions across the state. Child slavery or what it might be called was culturally accepted by our fathers and that we are seeing it as evil today and trying to stop it is facing different set back because poor parents are still sell their children today and poor families are still sending out their children to serve others for some fortunes. Mind you everybody cannot be rich at the same time (Ukana64, interviewed on 9/7/2019).

Inherited Practice and Child Labour

From gathered information through interviews, the fact that people still believe that nothing is wrong in children working to feed their parents is a great factor that influences continuity of these social menace against children in Akwa Ibom State. People are living under the fact that the inherited practice of having children work for their parents gives the moral position for sending children out to hawk on the streets or serve someone as housemaid.

A study participant in in-depth interview aged 36 years narrated that:

> *Our people believe that nothing is wrong if a child suffers for his or her parent. I do remember how I used to sell Akara in village*

> *for my grandmother in the morning before I will go to school. Because I lived with her, my mother and every other person felt it was the right thing my mother did to send me to go and lived with her so that I can sell Akara for her before going to school and help her with other house chores after school, but one thing my mother later came to realized was that I didn't use to attend school again because I will not want to be beaten for going to school late, and I joined a bad gang of students who go to school late and will not attend classes. When my result was out my mother beat me for poor result. But thank God a good neighbour told her to take me back and change school for me. This is why so many children are suffering today, and why so many "to be good children" ended up being "bad children" because of street of gang influences (Aniefiok 36, interviewed 9/7/2019).*

"*Akudaduubok*" (Grow-up to feed your parent) is found to be a cultural proverb among the people of Akwa Ibom State. As gathered from interview by the researcher, the people believe that it is a culture that children should grow to feed their parents. Therefore the people have adopted many strategies and approaches toward reaping the fruits of having children. Having or forcing the children to hawk on the streets or serve as maids is found my some of the study respondents as part of the fulfillment of *"akudaduubok".* The challenge of this cultural practice is found to be the fact most parents do not know that this cultural proverb is not applicable to children under the age of 18 years. Information gathered by the researcher revealed that this proverb has been abused by most of the parents among Akwa Ibom people.

A study participant aged 33 years in his reaction to questions said that:

> I used to hear that *"eyen edi Okuda du ubok"* (a child is to grow and take care of his/her parents). I agree with quite well, but I don't think that this refers to children under the age of 18 years, as these children cannot make decision on their own and are at the age whereby they need care and support from their parents. But the opposite has been the case of many children you see along this Abak road. Many parents do not know that before you are qualified to be fed by your children, you must have fed them and given them good education for a foundation that can take care of you at your old age. But what do we have today? Parents and guardians hiding under *"eyen edi Okuda du ubok"* to exploit their own little children as you can see here (Frank 33, interviewed on 9/7/2019).

Another study respondent aged 47 years in her responses said that:

> *To me oh, the most important reason why you will continue to see children hawk by the streets is that most parents believe that it is their children responsibility to take care of them as their culture demands instead of them labouring to take care of their children and give the children good foundation so that the children can take care of them at their old age. Some parents want their children to take care of them from age 5 till they die. If a child labours to raise money for food at age 5 is it not that child that is feeding his or herself and his or her parent at the age he or she supposed to be fed and taken care of by the parents? (Akwaifiok 47, interviewed on 9/7/2019).*

Emerging fact from interviews is that some of these children are born into families that have the culture of depending on children for survival. Some of the study respondents in their responses agreed that some children are unfortunate to be born into families that look up to their children as hope for survival. According to them, such families will trade their children for their selfish reasons and live their life at the expense of their children freedom, joy, happiness and future.

One of the study respondents aged 35 years in her narratives reported that:

> *There are some of these children who must hawk by the street, not because they want to meet their personal needs, NO! It is because there are people at home who depend on whatever that the child will be coming back with. It is their way of life; Lazy parents who sit back at home while they expose their children to danger every day at the streets (Ntiense 35, interviewed on 9/7/2019).*

Child slavery according to the information gathered from the respondents is found to be rooted in the culture of the people and has been transferred from one generation to another. Emerging from the interviews is the fact that there exist many reasons for child labour especially in street hawking around the city of Uyo, but culture has a great influence over the reasons why there are children hawking by the streets of Uyo.

Discussion

Findings of the study show that modern day child slavery exists in Uyo metropolis in various forms of child labour with street hawking being one of the forms of child labour. Many children were found along Abak Road, Aka Road, Ibom Plaza, Ikpa Road Junction, Ekom Iman Junction, Itam Junction, Oron Road, Four Lane Junction by Oron Road, Idoro Road, Nwaniba Road, Akwa Ibom State Secretariat, Udo Unmana Road, Ikot Ekpene Road, and Urua Ekpa Junction. Street hawking is another form of modern day child slavery that has received the support of some parents within the state. Findings of the study show that parents and guardians play great role in the prevalent nature of this social problem found within the territory of our state capital. This agrees with Aqil (2012) view that; when parents have worked in their childhood their children will work as well, passing it from generation to a generation.

Culture can be said to be that complex whole adopted by a given group of people or society as their way of life. Findings of the study revealed that child labour is rooted in the culture of Akwa Ibom people right from the pre-colonial era. Emergence from findings is the fact that cultural practices have great influence over modern day child slavery especially, in street hawking, and house maids. This agrees with Fawole, Jacob and Osungbade (2003) who argue that cultural beliefs in treating the children are also another cause of child abuse as children are seen more as mere properties of their parents. Findings further revealed that the challenge faced by the fight against modern day child slavery in Akwa Ibom State, in form of child trafficking and child abuse is due to the weight of cultural influence over child labour among the people of the state.

It was revealed by findings of the study that most people within Uyo metropolis still believe that nothing is wrong in children working to feed their parents. This cultural belief was found to be a great factor that influences continuity of this social menace against children in Akwa Ibom State. Findings of the study also revealed that "*Akudaduubok*" (Grow-up to feed your parent) is found to be a cultural proverb among the people of Akwa Ibom State, which people are hiding under as inherited practice of having children work for their parents andas a moral position for sending their children out to hawk on the streets or serve someone as housemaid.

Emerging from the findings of the study is the fact that people have adopted many strategies and approaches toward reaping the fruits of having their children working for them within Uyo metropolis. These set or class of people feel that having or forcing their children to hawk on the streets or serve as maids is part of the fulfilment of *"akudaduubok".* Findings of the study show that most of these parents do not know that this cultural proverb is not applicable to children under the age of 18 years.

Conclusion

Factors like parents, cultural belief, and poverty play key roles in the prevalence nature of street hawking by children found within Uyo

metropolis in Akwa Ibom State. Street hawking as a form of child labour is a serious aspect of modern-day child slavery because of the impacts of this social menace on Akwa Ibom children. Parents and guardians have consistently played behind the scene roles in promoting this act of slavery. The culture of *"akudaduubuk"* has been in the very act of sending out under aged children into the street to hawk for a living at the age whereby they are expected to be taken care of by their parents. This exposed the children to different forms of danger. The girls were said to face sexual assaults by the opposite sex on the streets, the children faced denial of access to right to Free and Compulsory Education Programme of the Akwa Ibom State Government and most of them are working under hazardous weather and environmental conditions.

Recommendations

- Government should ban street hawking by children as form of investment by parents and guardians.
- The cultural ideology of "Akudaduubok" should be abolished among Akwa Ibom people in order to raise a sense of responsibility among parents across Akwa Ibom State.

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Assessment Of The Locational Distribution And Operations Of Football Academies In Uyo Capital City, Akwa Ibom State

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Abstract: The *aim of this study was to assess the contributions of football academies to the socio-economic development of Uyo Capital City, Akwa Ibom State. It was achieved using the following objectives; to identify the locational distribution of football academies in Uyo Capital City; to examine the day-to-day operations of the football academies in Uyo Capital City. The conceptual framework was built on the concept of youth football. The research design that was used for the study is both the survey and descriptive methods. Data obtained from primary and secondary sources showed that only two out of the ten football academies are located on the fringes of Uyo Capital City while the remaining eight are located in the heart of the study area. Thus, people at the fringes of the study area do not have access to the football academies as much as those in the heart of the study area. The study indicated that the football academies in Uyo Capital City had one training centre each. This shows that the football academies are run at small scale and do not possess the capacity that can enable them establish more centres. It was recommended that the existing football academies can expand their training centres to accommodate people who have been excluded.*

Keywords: Football, Football Academies, Locational distribution, Operations, Uyo

CITATION:
Wilcox, R. I. and Udofot, N. E.(2023). Assessment of the Locational Distribution and Operations of Football Academies in Uyo Capital City, Akwa Ibom State. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 602-613

Introduction

Football is the most popular sport in the world and one of the most popular in Nigeria, capable of attracting large crowds from different countries and very different cultures. It is not only an abiding passion, but today it has important economic and social aspects (Campos, 2015). In Europe and North America, sports are increasingly important to the economy. About 2 million people are employed in the sports economy in the 15 member countries of the European Union – that is, 1.3% of overall EU employment. And the sports economy is growing (Mendoza, 2017). In Europe, in the early 1970s, the ratio of overall sport expenditures (for goods and services) to GDP was around 0.5%. In 1990, the ratio ranged between 1 and 1.5 per cent of GDP in most European countries (Andreff and Szymanski, 2006). In the UK, the contribution of the sports economy to GDP is currently estimated at more than 2%. As a comparison: this is three times as high as the current contribution of agriculture to GDP in the UK.

Sports teams including their investments in football academies have become large commercial and often multinational enterprises. For example, the value of Manchester United is estimated at 4.7 billion dollars in 2021, which is more than the total annual output (GDP) of a country like Sierra Leone (FIFA, 2021). The richest football clubs in the European champions' league are valued at over $1 billion each. For example, Manchester United together with its football academy is valued at over $4.7

billion while Chelsea football club and its academy are valued at $14.5 billion and Manchester City is valued at over $22 billion (Forbes, 2021). All these go a long way to show that investment in football and football academies have become serious business for the owners and for the respective economies.

Over the years, football academies have played a major role in the development of the beautiful game in West Africa (Mensah, 2019). Apart from helping to mitigate the issue of trafficking young and unsuspecting African youths to labour on the cold streets of Europe, football academies have given meaning to the business angle of running football. They have also helped in shaping the career of would-be professional footballers through literacy classes and counselling sessions. Notwithstanding the alarming proportion at which mushroom academies are springing up in West Africa, there are a few notable ones which have gained international recognition and have produced quality players for major clubs in Europe and elsewhere in the world.

In Nigeria, there is great love and passion for the game of football. Based on this, football academies have also been established to promote the game of football (Olawale, 2021). These academies include PEPSI Football Academy, Kaduna; Kwara state Football Academy, Abuja Football College, Midas Soccer Aacademy, Papillo Football Academy, Barcelona Football Academy, Chelsea Football Academy, International Soccer Academy and others. These academies help groom players, offer scholarships abroad and discover and nurture football talents in Nigeria (Olawale, 2021).

However, comparable and representative data on the economic value of football are not available, especially for developing countries. The operations of football academies vary across space but they have some things in common. Football academies train young ones to develop into first team players, become a reserve or squad player or to make money for football clubs through sales of players, transfer or compensation schemes (Olawale, 2021). Several studies have looked at the business of football from different dimensions but the study of football academies and their operations is a relatively new terrain and therefore there is paucity of literature in this area. It is therefore imperative to look at football academies location, their operations, training of young ones and their socio-economic impacts on areas such as income, employment, transportation, infrastructure, businesses and other livelihood issues. The aim of this study was to assess the contributions of football academies to the socio-economic development of Uyo Capital City, Akwa Ibom State.

Materials and methods

Study Area

Uyo Capital City is a fast-growing area located in South-South Nigeria. It serves as the capital of Akwa Ibom State. It is located approximately between latitudes $4°05^{1}$ and $5°30^{1}$N and longitudes $7°50^{1}$ and $8°30^{1}$E with a land area of approximately 362 km^2. It is bounded on the North by Itu, Ibiono Ibom and Ikono Local Government Areas, in the East by Uruan Local Government Area, south by Etinan and Ibesikpo Asutan Local Government Areas (Abraham, Saturday, Tom, and Ibanga, 2018)

Football academies are distributed differently across the world. In Europe alone, there are over 100 football academies across the continent with Spain (18), Italy (16) and France (9) having the highest numbers respectively. These football academies help to train and refine young talents into professional football (Clinton, 2017).

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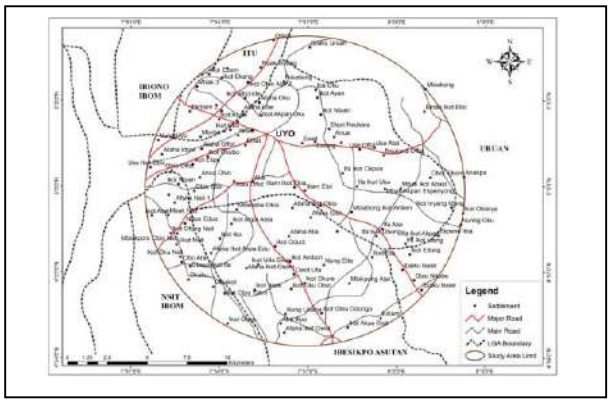

Fig. 1: Map of Uyo Capital City, Akwa Ibom State, Nigeri

In America, football academies dot the landscape and they are classified into free, paid and elite football academies depending on their mode of admission. Football clubs like Barcelona FC own up to four football academies and they include High performance football academy, Barcelona; High performance football academy, Valencia; High performance football academy, England and FC Barcelona high performance football academy, USA (Ertheo, 2021). The aim of these academies is to allow young ones to combine their studies with a professional soccer player training and also to enable the young ones win university scholarships. In South America, there are seven major football academies across the continent which has other smaller academies operating under them. Brazil alone has more than twenty football academies operating under the Brazilian Soccer Academy and study abroad programmes (IFX, 2021).

Coming down to Africa, there are also many football academies dotting the landscape, with the Pepsi Football Academy (PFA) and the West Africa Football Academy (WAFA) being the most popular (FIFA, 2021). The Pepsi Football Academy was formed in 1992 in Lagos with the backing of the Lagos state sports council and Pepsi Nigeria Limited with the aim of raising young footballers who would take over from the older generation. Over the years, PFA has grown into one of the most prestigious football academies in (Africa and West Africa) with over 4,000 students aged between 6-18 years, 14 separate training centres and over 60 coaches across Nigeria alone (Sanni, 2021). In Nigeria, there are other football clubs operating apart from the PFA. These include FC Barcelona football academy (FCBESCOLA) which operates from the Teslim Balogun stadium, Lagos; Kwara State Football Academy (KWFA) which operates from Ilorin and is the only state sponsored football academy; Abuja football college (AFC) which operates from Wuse, Abuja; Midas Soccer Academy which is affiliated to the Nigerian Football Federation and the Papilo Football Academy (PNKFA) founded by former super eagles player, Kanu Nwankwo and operates from Egbu road, Owerri (Hale, 2021). It is also worthy of note that in Akwa Ibom state, there is Carabana football Academy founded by Rt. Hon Nse Essien in 2018 and it operates from the Akwa Ibom State House of Assembly Complex in Uyo. All these academies have succeeded in training young players at home and abroad for the soccer industry. Other football academies in the area include; Pillars Investors Football Academy, Blessed Stars Football Academy, Dahlia Football Academy, Anyibest Sport World, Mackmirel Football Club, Skydove Football Club, Rapture FC Academy, Vandrezzer FC Academy and Eagle Eye Football Academy.

The day-to-day operations of football academies are almost the same across landscapes. Clinton (2017) opined that the running of a football academy is guided by six fundamental principles which include; Increasing the number and quality of home grown players gaining professional contracts in the clubs and playing first team football at the highest level; Creating more time for players to play and be coached; Improving coaching provision; Implementing a system of effective measurement and quality assurance; Positively influencing strategic investment into the Academy System demonstrating value for money and seeking to implement significant

gains in every aspect of player development (Clinton, 2017; Premier League, 2014).

In another study, Klobučník *et al*., (2019) in their study of football clubs' sports performance in the context of their market value and GDP in the European Union regions opined that the basic operations of football academies include; physical preparation of young players, physical conditioning in modern football using different methodological and scientific approach, training in the physical demands of football (speed, coordination, strength speed, endurance speed, strength, endurance, endurance strength, flexibility), training coordination skills, endurance training, strength in football, speed in football, recovery/regeneration and physical tests for young players. Klobučník *et al*., (2019) further stated that football academies do not only train young ones to be footballers but they are also involved in the mental and educational aspects of basic training. In the educational aspects of basic training, players are taught the educational potential of football, education in fair play (respect) and education in performance (self-confidence). In the mental training, players are taught determination, risk taking, concentration, positive attitude, care, discipline, self-control, self-confidence, resistance to stress, courage, psychological stamina, competitiveness, cooperation, communication, personal motivation and drive for improvement.

Concept of Youth Football

Youth football has been described as a type of football that engages people of between 6 and 23 years of age. Union of European Football Associations (UEFA) includes "children's football, school or youth football, amateur football, football for disabled players, even football for veterans. In short, it is the football played by the masses at a level where participation and a love of the game are paramount" (Union of European Football Associations, 2011). Mrkonjic *et al*., (2016) suggested that youth football competition should be divided into three segments which are;

The first segment refers to children's football and usually comprises young players aged between 6 and 12. In this respect, we follow FIFA's understanding of "grassroots football" (FIFA, 2015). The competitions should be framed in order to allow children to be (simply) introduced to the game of football. Indeed, one should keep in mind that during that period, it is probably their first experience of football. But it is also not excluded that they practice other sports in parallel. As a concrete example, a study on sport participation in Switzerland (Lamprecht, Fischer, Wiegand, and Stamm, 2015) observed that even if football remains the most popular sport, there is a strong tendency among young boys and girls aged between 10 and 14 years for multi-sport practice. During this introductory stage, the contributors conveyed to the session a strong emphasis on the installation of values such as enjoyment, fun, friendship and physical and mental health. Nevertheless, children can also be trained with basic and fundamental football skills, as it is assumed that they could potentially become elite players in the future. The organisation should also be focused on increasing and ensuring regular participation and presence at training sessions and games rather than identifying and promoting future talent through performance-based selection. Regarding competition format, emphasis should be given to small-sided games (five-aside, seven-a-side, and nine-a-side) and short competitions (2x15 min, 2x20 min, and 2x25 min) which can also take the form of festivals or tournaments. For technical and motivational reasons, the use of large-sized pitches should be avoided as far as possible. Usually, children should not spend too much time and resources to access the pitch. Finally, since fun and discovery are given primary importance, separating gender categories is not a key priority at this age. The teams can be mixed. Over-formalisation of the regulatory

frame of the competition should not be a priority. During this age period, adopting a basic set of rules is fairly acceptable to allow children to have fun with their team mates and friends. Finally, there appears to be no predominant setting regarding the organisation of youth competitions at a national level. In some countries (e.g., in Mali), children's football might also be excluded from our understanding of organised football or simply be organised at a local level.

The second segment refers to non-elite youth football and usually includes players aged between 13 and 23. More than an introduction to the game, the objective consists of maintaining youth participating in the game. Similarly, to children's football, the contributors suggest placing an emphasis on the promotion of social values, such as fair play, friendship and respect, but for this particular segment, the format of the competition should not be of primary importance as long as the players have access to enough matches. From a regulatory perspective, competitions should be organised with a limited number of rules which can be modified from competition to competition, rather than by steady and strict regulation and harmonisation across competitions. For this segment, Non-MAYFC appears to be the predominant setting, including namely NGOs, which put a strong emphasis on the transmission of social values and empowerment of youth through the game of football.

The third segment refers to elite youth football and also includes youth aged between 13 and 23 years. It is, however, different from the second as its main objectives consist of achieving performance goals and developing sporting competition. Youth participation is driven by a (potential) career as a professional football player, success, wins and personal achievement. The organiser should, therefore, give particular emphasis to the steady progression of the players but also to motivation and retention. This is particularly important as usually a significant amount of (financial) resources have already been invested since the beginning of their football development journey (notably in Europe). Regarding competition format, matches should ideally be played on large sized pitches and eleven aside, in particular for the older age groups. In order to allow for progression, enough competitive matches should be organised (about 40 matches a year). Teams are predominantly separated (boys + girls). From a more regulatory perspective, regulation and harmonisation is needed as more games are played at international level. For this segment, MAYFC appears to be the predominant setting regarding the organisation of youth competitions at a national level, but it can also include performance oriented private academies that organise tournaments with a strong emphasis on player development.

Moreover, the evolution and transition of the players from one segment to another and the permeability of the related boundaries should also be taken into account. At any time, and for several reasons (e.g., de-motivation, financial uncertainty or life choice), a player taking part in elite youth football competitions can exit this segment for the non-elite path. Although rarer, the opposite can also be possible. In order to guarantee widespread participation, to maintain motivation and offer possibilities of sporting development, it is paramount to leave these doors as open as possible.

The discussion on the definition of a youth football competition and its *raison d'être* shows that the model should be flexible and adapted to each of the contexts of implementation. The understanding of the three football segments (children's football, elite football and non-elite football) and the characteristics of the attributes will, of course, depend on organisational conditions but also on the political, social, economic and sporting environment in which the country operates. In some countries, maybe the

three football segments do not exist, or even fall outside the organised pattern, which is especially true for children's football. They can also be labelled with different names such as "amateur", "vocational", "leisure" or "professional". Building on these observations and on the basis of the main tenets of the conceptual model, we suggest that each country segments its own youth football landscape, namely in the light of the opportunities and challenges of taking (or not) into account the reality of unorganised football. Youth football is the bedrock of football academies and its operations.

Methodology

In this study, the type of sampling technique used is a non-probabilistic sampling technique (a type of sampling in which the researcher selects samples based on the subjective judgment of the researcher) (Kumar, 2011). The type of non-probabilistic approach that was used is the purposive sampling technique. In this technique, the identified research participants helped recruit other participants for the study (Kumar, 2011). The justification is based on the limited number of full-time football academy owners and managers that have expertise in the area being researched.

The sample size included all the currently existing football academies located within Uyo Capital City, those managing them and people in the host communities. The sample size was determined using 10% adequacy formula as shown in the Table 1.

Table 1: Research Population

Population		Sample
Fans (people who go to watch trainings)		300
Footballers		50
Service providers	Coaches	20
	Medicals	5
	Curators	5
	Managers	10
Total		390

Source: Researchers Calculation (2021)

For the host community, the Godden (2004) formula of sample size determination was used;

$$SS = \frac{Z^2*(P)*(1-P)}{C^2}$$

Where:

SS = sample size,

Z = given Z value = 1.96 for 95% confidence level (from the z-score table)

P = Percentage of population

C = Confidence Interval = 0.05 for 95% confidence level

Thus,

$$SS = \frac{1.96^2 * 0.10 * (1-0.10)}{(0.05)^2}$$

$$= \frac{3.8416 * 0.10 * (0.90)}{(0.0025)}$$

= 138.3 = 138 questionnaires.

Data collection was by

(i) Structured Questionnaire

The first part of the questionnaire collected information on the characteristics of the respondents while the second part collected data on the research objectives.

The questionnaire design process involved breaking the research questions into smaller units and using the smaller units to design questions for the questionnaire. The questionnaire was distributed by targeting the respondents directly and this was to ensure privacy and reduce pressure while filling the forms. The questionnaire contained twenty (20) questions in all to encourage respondents to fill it.

All the data collected were coded and transferred into a spreadsheet (Microsoft excel) and they were presented using tables, charts, percentages and frequencies. This presentation approach aided visualisation of information even by non-experts.

Results

Table 2: Locational distribution of Football Academies in Uyo Capital city

S/N	Name of Football Academy	Year Formed	Location
1	Carabana Football Academy, Uyo	2018	Akwa Ibom State house of Assembly Complex, Udo Udoma Avenue, Uyo.
2	Pillars Investors Football Academy, Uyo	2016	24 Dr Edet Effiong Street, Off Akpan Essien Street, Uyo
3	Blessed Stars Football Academy, Uyo.	2016	Nwaniba road (close to St Joseph's Orphanage, Anua)
4	Dahlia Football Academy	2013	Ikot Udo, Ibesikpo
5	Mackmirel football academy	2014	Ito Ika, Ibiono
6	Rapture Football Club Academy, Uyo	2015	Ewet Housing Estate, Uyo.
7	Vandrezzer Football Club, Uyo	2017	15 Justice Edet Robert Nkop Avenue, Shelter Afrique, Uyo.
8	Eagle Eye Football Academy, Uyo	2015	Ewet Housing Estate, Uyo.
9	FC One Rocket Academy	2015	Henry Asuquo Street, Osong Ama Estate, Uyo.
10	Anyibest Sport World	2016	Aka road, Uyo.

Source: Researchers Compilation (2021)

Table 2 indicated the locational distribution of the football academies in Uyo Capital City. Two out of the ten football academies were located on the fringes of Uyo Capital City while the remaining eight were located in the heart of the study area. This could point out that the people at the fringes of the study area do not have access to the football academies as the people in the heart of the study area. Also, it was observed that even within the study area, the football academies were located in the elitist areas of Ewet housing Estate and Osong Ama Estate. From this it can also be deduced that the football academies may not be open to the non-elitist population.

The study also attempted to determine the day-to-day operations of the football academies in the study area. Two of the variables considered were the age bracket admitted into the academy and the number of training centres the academies have. The age bracket admitted was considered because it is a fundamental guide to the operations of the academies. The results are presented in Table 3.

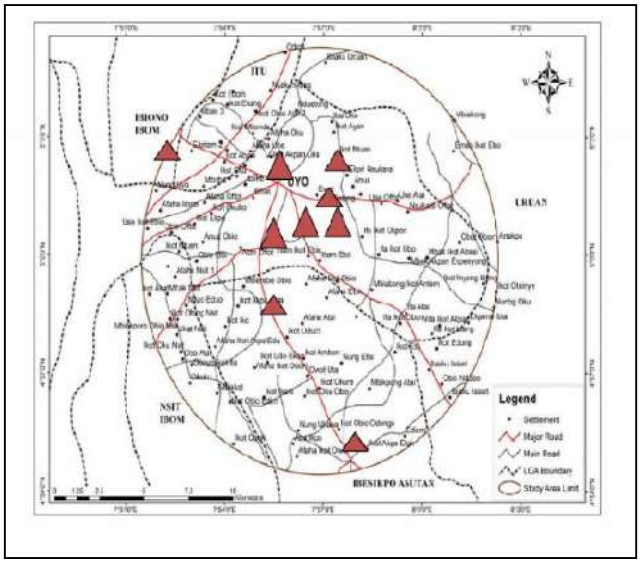

Fig. 2: Distribution of Football Academies in Uyo Capital City

The results obtained from the study indicated that the football academies in Uyo Capital City had one training centre each. This shows that the football academies were run at small scale level and do not possess the number or capacity that will enable them to establish more centres. Also, in the area of age bracket of admitted students, the table shows that four of the football academies (Pillars investors, Blessed stars, Rapture and Vandrezzer football academy) start admission from the age of 15 while the other six (Carabana, Dahlia, Mackmirel, Eagle eye, FC one rocket and Anyibest) admit students from the age of 18. But generally, the age of admission of students into these academies range from 15-21. The study also looked at the functions which the football academies perform as part of their day-to-day operations and the result of the study is shown in Fig. 3

Table 3: Recruitment of Young Talents by the Academies

S/N	FOOTBALL ACADEMY	AGE BRACKET ADMITTED	NUMBER OF TRAINING CENTRES
1	Carabana Football Academy, Uyo	18-21	1
2	Pillars Investors Football Academy, Uyo	15-18, I8-21	1
3	Blessed Stars Football Academy, Uyo.	15-18, I8-21	1
4	Dahlia Football Academy	18-21	1
5	Mackmirel football academy	18-21	1
6	Rapture Football Club Academy, Uyo	15-18, I8-21	1
7	Vandrezzer Football Club, Uyo	15-18, I8-21	1
8	Eagle Eye Football Academy, Uyo	15-18, I8-21	1
9	FC One Rocket Academy	18-21	1
10	Anyibest Sport World	18-21	1

Source: Researchers Compilation (2021)

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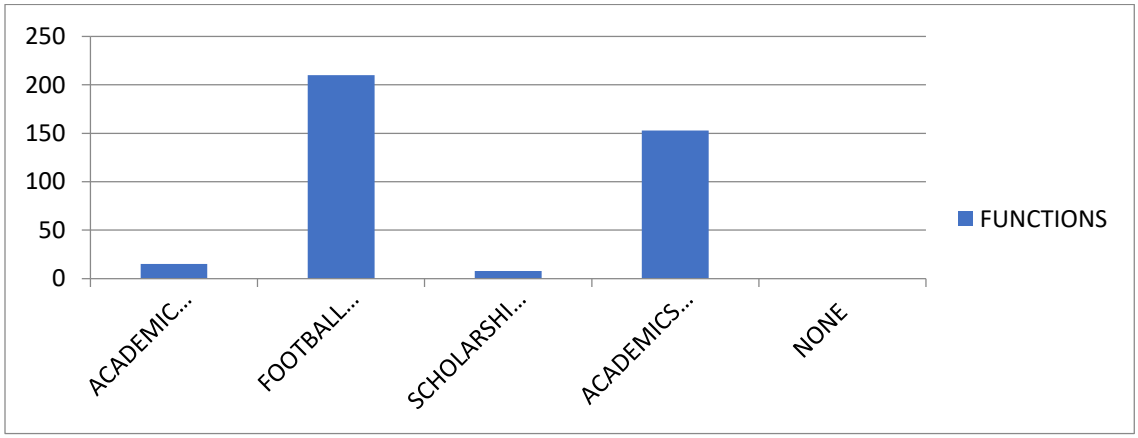

Fig. 3: Functions of football academies

Fig. 3 indicated that not everyone recruited was given academic training. this is as a result of the financial status of the academies. The major function performed by the football academies is the training of footballers in football skills, others perform a mixture of training the students in academics and also football skills and the least function is the giving of scholarships to footballers for training outside the country. These results show that the football academies in the study area are mostly interested in training people in football skills and not necessarily

academics therefore defeating the goals of being called football academies. It could also be because of financial constraints that the academies stick to football skills training instead of both skills and academics.

Furthermore, the study also tried to assess the guiding principles used for the day-to-day operations of the football academies and the result is shown in Table 4.

Table 4: Operational guiding principles for football academies

S/N	PRINCIPLES	FREQUENCY	%
1	Increasing the number of home-grown players for professional jobs	197	50.51
2	Creating more time for coaching	39	10
3	Increasing players play time	31	7.95
4	Effective quality assurance among players	39	10
5	Player development gains	20	5.13
6	Investment into academy system while demonstrating value for money	46	11.8
7	Others	18	4.62
	TOTAL	**390**	**100**

Source: Researchers Compilation (2021)

The result of the study indicated that the major guiding principle of football clubs was to increase the number of home-grown players for professional jobs (50.51%) in bigger leagues and clubs. The next guiding principle is the investment into academy system while demonstrating value for money (11.8%). The guiding principles show that half of the football academies operate for increasing the number of home-grown players for professional jobs. This principle is what generates money for the academies and which makes them focus on it.

To further strengthen the results of the study, the day-to-day operations of the football academies were looked at and then the following results were generated;

Table 5: Day to Day Training Activities of Football Academies

S/N	Activities	Frequency	Percentage
1	Physical preparation of young players	112	28.7
2	Physical conditioning in modern football using different methodological and scientific approach	34	8.7
3	Training in the physical demands of football (speed, coordination, strength speed, endurance speed, strength, endurance, endurance strength, flexibility)	93	23.9
4	Training in coordination skills	76	19.5
5	Endurance training	16	4.1
6	Strength in football/speed in football	33	8.5
7	Recovery/regeneration	11	2.8
8	Physical tests for young players	25	6.4
	TOTAL	**390**	**100**

Source: Researcher's Compilation (2021)

The results of the study indicated that the major daily activity of the football academies was the physical preparation of players (28.7%). The next major activity was the training in the physical

demands of football (speed, coordination, strength speed, endurance speed, strength, endurance, endurance strength, flexibility) (23.9%) and the third major activity was the training in co-ordination skills (19.5%). The result of the study show that the physical training and fitness of the footballers was the major aim of the academies and this is evident in their day-to-day operations. It corroborated the earlier result presented in Fig. 4 which showed that the academies were interested in skills training than in academics.

Football is a game that requires mental effort, therefore, the study tried to ascertain the mental training given to the footballers and the following result were obtained;

Table 6: Mental Training in Football Academies

S/N	Mental and Educational Activities	Frequency	Percentage
1	Educational potential of football	15	3.9
2	Education in fair play (respect)	23	5.9
3	Education in performance (self-confidence)	41	10.5
4	Mental training (determination, risk taking, concentration, positive attitude)	78	20
5	Mental training (care, discipline, self-control, self-confidence, resistance to stress)	49	12.6
6	Mental training (courage, psychological stamina, competitiveness)	73	18.7
7	Mental training (drive for improvement)	38	9.7
8	Mental training (cooperation, communication, personal motivation)	73	18.7
	TOTAL	**390**	**100**

Source: Researcher Compilation (2021)

The study indicated that more mental training was given in the area of courage, psychological stamina, competitiveness, cooperation, communication and personal motivation (18.7% respectively). The next area of mental training was in the area of care, discipline, self-control, self-confidence and resistance to stress (12.6%). The mental training was dome to prepare players for professional football in the bigger leagues.

Discussion

The results of the study indicated that two out of the ten football academies are located on the fringes of Uyo Capital City while the remaining eight are located in the heart of the study area. This could point out that the people at the fringes of the study area do not have access to the football academies as the people in the heart of the study area. Also, it was observed that even within the study area, the football academies are located in the elitist areas of Ewet Housing Estate and Osong Ama Estate. From this it can also be deduced that the football academies may not be open to the non-elitist population. This agrees with the studies of Ertheo (2021) who opined that in America, football academies dot the landscape and they are classified into free, paid and elite football academies depending on their mode of admission. Football clubs like Barclona FC own up to four football academies and they include High performance football academy, Barcelona; High performance football academy, Valencia; High performance football academy, England and FC Barcelona high performance football academy, USA (Ertheo, 2021). The aim of these academies is to allow young ones to combine their studies with a professional soccer player training and also to enable the young ones win university scholarships.

In addition, the results obtained from the study indicated that the football academies in Uyo Capital City had one training centre each. This

shows that the football academies are run at small scale level and do not possess the number or capacity that will enable them to establish more centres. Also, in the area of age bracket of admitted students, the table shows that four of the football academies (Pillars investors, Blessed stars, Rapture and Vandrezzer football academy) start admission from the age of 15 while the other six (Carabana, Dahlia, Mackmirel, Eagle eye, FC one rocket and Anyibest) admit student from the age of 18. But generally, the age of admission of students into these academies range from 15-21. This result differs a bit from the study of Sanni (2021) who reported that the Pepsi Football Academy which was formed in 1992 in Lagos with the backing of the Lagos state sports council and Pepsi Nigeria Limited with the aim of raising young footballers who would take over from the older generation. Over the years, PFA has grown into one of the most prestigious football academies in (Africa and West Africa) with over 4,000 students aged between 6-18 years, 14 separate training centres and over 60 coaches across Nigeria alone (Sanni, 2021).

Furthermore, the result of the study indicated that the major guiding principle of football clubs was to increase the number of home-grown players for professional jobs (50.51 percent) in bigger leagues and clubs. The next guiding principle is the investment into academy system while demonstrating value for money (11.8%). The guiding principles show that half of the football academies operate for increasing the number of home-grown players for professional jobs. This principle is what generates money for the academies and which makes them focus on it. This agrees with the study of Clinton (2017), where Clinton opined that the running of a football academy is guided by six fundamental principles which include; Increasing the number and quality of home grown players gaining professional contracts in the clubs and playing first team football at the highest level; Creating more time for players to play and be coached; Improving coaching provision; Implementing a system of effective measurement and quality assurance; Positively influencing strategic investment into the Academy System demonstrating value for money and seeking to implement significant gains in every aspect of player development (Clinton, 2017; Premier League, 2014).

Furthermore, the results of the study indicated that the major daily activity of the football academies was the physical preparation of players. The next major activity was the training in the physical demands of football (speed, coordination, strength speed, endurance speed, strength, endurance, endurance strength, flexibility) and the third major activity was the training in co-ordination skills. The result of the study show that the physical training and fitness of the footballers was the major aim of the academies and this is evident in their day-to-day operations. It corroborated the earlier study of Klobučník *et al*., (2019) in their study of football clubs' sports performance in the context of their market value and GDP in the European Union regions, which opined that the basic operations of football academies include; physical preparation of young players, physical conditioning in modern football using different methodological and scientific approach, training in the physical demands of football (speed, coordination, strength speed, endurance speed, strength, endurance, endurance strength, flexibility), training coordination skills, endurance training, strength in football, speed in football, recovery/regeneration and physical tests for young players.

Conclusion and Recommendations

The football academies in the study area were not proportionally distributed. It was therefore concluded that even within the study area, the football academies were located in the elitist areas of Ewet Housing Estate and Osong Ama Estate. From this it can also be deduced that the

football academies may not be open to the non-elitist population.

It was also concluded that the football academies were run at small scale level and do not possess the number or capacity that will enable them to establish more centres. It was also concluded that the major guiding principle of football clubs was to increase the number of home-grown players for professional jobs (50.51%) in bigger leagues and clubs. The result of the study also led to the conclusion that the physical training and fitness of the footballers was the major aim of the academies and this is evident in their day-to-day operations.

In line with the conclusions drawn from the study, the following recommendations were made; The current distribution of the football academies does not favour the incorporation of the general population into the football business. It is therefore recommended that the existing football academies can expand their training centres to be able to accommodate people who cannot reach their current training centres and also the expansion of training centres will help create more awareness about the academies. It is also recommended that instead of just focusing on the development of football skills among players, the football academies can also develop a viable educational curriculum or use the existing curriculum to boost their activities and give the players other options after their football career.

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Estimation Of Agricultural Export And Import Intensity Indices In Nigeria: 1990-2020

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Abstract: *This study estimated the trends, composition and trade intensity of Nigeria's agricultural commodities with her trading partners for the period 2000-2021. Secondary data obtained from Annual Reports of Central Bank of Nigeria (Various issues) and statistical Bulletin of National Bureau of Statistics (Various issues) were used for the study. The data were analyzed with a combination of mean, percentages, graphs, trade intensity index, multiple regression model based on OLS estimation techniques. The Augmented Dickey Fuller (ADF) was employed to verify the stationarity of the variables and error correction models was used to investigate existence of co-integration among variables. The results indicate that Nigeria's trade with other partners has significantly recorded impressive growth. However, the share of major products exported to industrial nation, Asian countries and Africa over the period remains insignificant. The results further show that the share of major products imported from its trading partners is significant, indicating that world exports to Nigeria are more diversified than that of Nigeria's export to its trading partners. The ADF test revealed that at first difference however, all the series became stationary. The result further shows that, on average, industrial nations had an export index of 1.81 with Nigeria and import index of 2.42 for the period under review. The trade index indicates high trade intensities between Nigeria and industrial nations and the high possibility of increasing bilateral trade flow. However, the share of major products exported to these countries over the period was insignificant. Result from ordinary least square regression analysis shows that agricultural export (AGREXP), agricultural degree of openness (ADO), and real exchange rate (REXR) were statistically significant at different levels of probability. It was recommended that, regulating these macro-economic variables will promote agricultural export performance hence, agricultural trade intensity.*

Keywords: *AgriculturaL Export Import, Trade Intensity Indices, Economic Growth*

CITATION:

Akpan, O. D. Obinaju, L. C. and Etim, S. M.(2023). Estimation of Agricultural Export and Import Intensity Indices in Nigeria: 1990-2020. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 591-601

Introduction

International trade is an economic activity that involves nations with dissimilarities in natural resources endowment as well as comparativeness in production of exportable goods and services. Due to the pace of global trade, integration in the second half of the 20th century reflected the increasing contribution of commerce to the global economy, positioning itself as a fundamental growth engine for most countries. Between 1990 and 2008, the worlds gross domestic product (GDP) increased by over 60% and was attributed to the share of total merchandise. This was accompanied by the expansion of trade, which as an important dimension of economic integration was supported by strong role of the emerging economies. For instance, in 1990 merchandise

trade represented 19% of the emerging economies' GDP, and in 2008, this share amounted to more than one-third. Trade between some countries in the Mediterranean region also experienced a significant increase in 2018, which represented an important part of the region's economy, namely, 35% of the GDP. OECD (2017), reported that trade in services began to increase in the last quarter of the 20th century – and more strongly in the beginning of the 21st century, with an increase of 125% between 2005 and 2018.

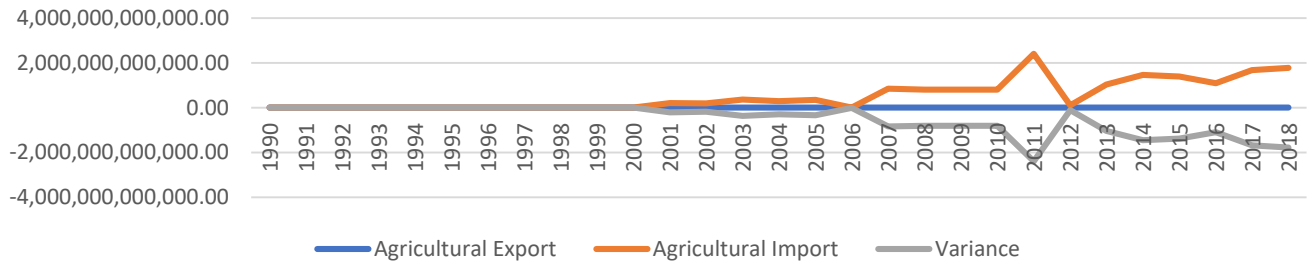
However, the Nigeria agricultural sector has over the years suffered major setbacks in terms of policies inconsistency, low government investment and budgetary allocations, as well as technological development in the value chain subsector. For instance, analysis by the Nigerian Export Promotion Council (NEPC, 2020) showed that, the total amount of estimated untapped potential by 2021 for Nigerian exports of cocoa beans to the ten best markets (Germany, Malaysia, Singapore, Turkey, Netherlands, Italy, Japan, France, Mexico and Indonesia) is around $425 million, $81.9 million worth of cocoa butter, while the value for untapped potential in the market for cocoa paste by 2021 stood at $6.3 million (approximately 3.5 trillion Naira). The untapped market potential for sesame seeds to the top ten markets (China, Japan, South Korea, Mexico, Poland, France, Lebanon, the United States, Canada and the UK) is estimated at US$170 million. (7,650,000,000 Naira). The export intensity index compares the share of exports to each country in Nigeria's total exports, with the share of world exports going to that country, and therefore gives a measure of the importance of that country to Nigeria as an export destination. A higher number denotes a stronger relationship, and an index of one indicates that exports to that country are what would be expected given global trade patterns. According to NBS (2020), the Asia region is the leading importer of Nigeria's agricultural commodities as shown in Figure 1. The region accounted for 59% of total exports in 2018, as Europe contributed 34.5% and America (3.6%) and are the second and third biggest markets for Nigeria's agricultural goods in 2018. Export value of agricultural goods to Asia in 2018, grew by 167%, from N67.3 billion in 2017 to N179.6 billion. The growth was mainly driven by demands from Japan, India and China. Trade in agricultural goods between Nigeria and the rest of Africa is still relatively small compared to other regions of the world. Agricultural exports to other African countries declined by 6%, from N4.1 billion in 2017 to N3.9 billion in 2018.

The sector accounts for about 70% of the nation's employment, and is divided into four main subsectors. These subsectors are crop production, livestock, forestry and fishery in order of contribution to the nation's gross domestic product. In 2019, the contribution of agricultural sector to the nation's GDP stood at 25.3% (CBN Statistical Bulletin, 2020). The agricultural sector is considered one of the important sectors that push economic growth in developing countries, such as Nigeria. In terms of input–output linkages among different economic sectors, agriculture provides the main support for various economic activities, such as manufacturing, marketing, trade, and services, and in developing oil-exporting countries. Aiyedogbon and Ohwofasa (2016), noted that foreign trade creates an avenue for foreign capital to flow into a country, increasing the earnings and economic growth at large. Adenugba and Dipo (2013), described the Nigeria exports as a catalyst for the overall development which increase earnings of the nation's economy, thereby creating an avenue for growth by raising the national income of the country.

Over the years, the Nigerian economy has been described as mono-economy that fundamentally relies on the export of crude oil for the bulk of its foreign exchange earnings,

with little or no attention to the non-oil sector of the economy. In recent times, there have been serious advocacy for economic diversification, but this has not yielded the desired results as the government still counts heavily on revenue from oil for infrastructural financing and other basic responsibilities. To achieve this diversification, non-oil sector of the economy has been identified as a viable alternative, especially agriculture which was hitherto area of comparative advantage. However, the diversification efforts have not yielded substantial results. The Economic Complexity Index –ECI (2020) reported that, in 2019, Nigeria was the number 25th economy in the world in terms of GDP (current US$), the number 47 in total exports, the number 50 in total imports, the number 140 economy in terms of GDP per capita (current US$) and the number 140 most complex economy. The National Bureau of Statistics (NBS, 2020) recent data on foreign trade shows that the top ten agricultural products exported from Nigeria are estimated at ₦ 82.3 billion. There is a 9% decline in the revenue made from the top ten agricultural products in the first quarter of 2019, while the revenue of agricultural products export dropped from N91.2 billion generated in the last quarter of 2018, to ₦ 82.3 billion. Also, according to *National Bureau of Statistics NBS (2021), the total value of trade in agricultural goods from 2015 to 2021 was ₦ 6.2 trillion, comprising of ₦ 5.04 trillion from export and ₦ 1.14 trillion from import, leading to a trade deficit of ₦ 3.3 trillion*. Nigeria has recorded a continuous agricultural foreign trade deficit in the past five and a half years, with the highest being N503 billion recorded in first quarter of 2021, followed by the recent ₦ 486.8 billion recorded in second quarter of 2021. Meanwhile, Nigeria's GDP report shows that the agricultural sector has grown consistently positively in recent years but economic and development indices are declining and pointing to poverty and income inequality

Figure 1: Trend of Agricultural Export and Import in Nigeria



Despite the steady growth in the value of Nigeria's agriculture exports over the last six year, the country's agricultural exports contribution to total exports remained below 2%. Consequently, oil revenue continues to account for more than 80% of total value of annual exports, as such Nigeria has lost her role as one of the world's leading exporters of agricultural commodities. In addition, the country is currently faced with declining, as well as fluctuating income from its heavily dependence on oil exports, and with the present situation in the oil market, it has become necessary for the country to reconsider its agricultural export position.

In order for Nigeria to regain its position in international trade, export and import intensities have to be improved. This necessitates the need to examine the position of Nigeria agricultural export and import with its top trading partners. It is against this background that this study is aim at answering the following questions: What are the agricultural imports and exports intensity indices of trade in Nigeria and

their trading partners? What are the determinants of agricultural export in Nigeria's economic growth? To address these questions, the study sets the following objectives; to measure the import and export intensity indices of trade in Nigeria over the period and estimate the relationship between agricultural trade intensity and economic growth in Nigeria. The Justification of the study is based on agricultural sector as one of the leading sectors of the Nigeria economy. Since the sector's performance directly mirrors that of the overall economy, the results of the study are expected to assist researchers, policy makers, and relevant government agencies in their planning, research, development, and the use of agricultural output towards attaining food security.

Empirical and Theoretical Review Import and Export Intensity Indices of Trade in Nigeria

Several studies have examined Nigeria's trade relations with its trading partners with little attention to Nigeria's trade relations with Brazil, which presently is among its major trading partners. Ibrahim and Sayuti (2017), examined the comparative advantage between Nigeria and Brazil and measures the extent to which Nigeria's export supply matches with Brazil's import demand. The result showed that Nigeria can only competitively export few commodities compared to Brazil, and evidence from trade complementarity reveals the existence of a partial match between Nigeria's exports supply and Brazil's imports demand. Ibrahim and Iorember (2018) examined both products and sectoral comparative advantage in Nigeria-China trade relations and found that Nigeria has a long period comparative advantage in raw materials and mineral fuels export with robust export competitiveness and can export these products to China, while China can export to Nigeria mostly manufactured, capital and consumer goods with low exports competitiveness.

Ibrahim and Shehu (2016); Ibrahim (2015) and Ibrahim and Dilfraz (2014) studies revealed that Nigeria's exports to India are less diversified than that of India's export to Nigeria and major products imported from India from 2000 to 2014 accounts for higher significant share unlike the case of Nigeria's export to India. Loius and Adewuyi (2011) and Idris and Chukwuka (2011) showed that Nigeria's trade with West African countries is limited by similar or non-complementary production structures as agriculture dominates the GDP of most countries within the sub-region. Walther et al., (2012) identified seven important products that are mostly imported and re-exported along the Niger, Benin and Nigeria's borders to include cigarettes, cereals, flour, used clothing, oil, used vehicles, textile, and building materials. Similarly, Mombert and Fransis (2012) found that trade between Nigeria and Ghana lagged behind as a result of lack of regulatory reforms, informal payments and delays among many others. Abraham and Adekola (2014) in a study examined the impact of regional economic integration on the growth of Nigeria economy. The result showed that import and balance of trade are positively related to gross domestic product, while export has a negative relationship with the gross domestic product.Sabyasachi and Nuno (2013) examined the impact of common border, political globalization, economic size, and cultural proximity on India's bilateral trade flow with its major twenty trading partners including Nigeria. The result revealed that economic size of India's trading partners, common border, political globalization, and cultural proximity were positively and significantly influencing India's bilateral trade flows with its twenty largest trading partners including Nigeria. Sarath (2010) used the Trade Intensity Index (TII) and RCA Index to assess trade complementarities and similarities between India and Asian countries and found that complementarities are available for both trading partners to enhance trade cooperation in some sectors and products.

Agricultural Export and Economic Growth in Nigeria

Oji-Okoro (2011) employed multiple regression analysis to examine the contribution of agricultural sector to the Nigerian economic development. The researcher found a positive relationship between Gross Domestic Product (GDP) vis-à-vis domestic savings, government expenditure on agriculture and foreign direct investment between 1986 and 2007. It was also revealed in the study that, 81% of the variation in GDP could be explained by domestic savings, government expenditure and foreign direct investment. Olajide *et al*., (2012) analysed the relationship between agricultural resources and economic growth in Nigeria using the ordinary least square regression method. The results revealed a positive cause and effect relationship between Gross Domestic Product (GDP) and agricultural output in Nigeria. Agricultural sector is estimated to have contributed 34.4% variation in Gross Domestic Product (GDP) between 1970 and 2010 in Nigeria. Verter (2016) investigated the impact of economic growth on agricultural export in Nigeria. The study using secondary data, employed the Johansen Cointegration and Granger Causality. The study revealed a negative relationship between agricultural degree of openness and economic growth. Dawson (2015) reviewed the contribution of agricultural exports to economic growth in some developed countries. The study employed the fixed and random effects models using panel data of 62 LDCs for the period 1974–2005. The results of the study explained the role of agricultural exports on economic growth.

Ojo and Olufemi (2014) examined the causal relationship between agricultural export and economic growth in Nigeria, with the use of time series data from 1980 to 2012. The Phillips-Peron unit root, Johansen co-integration and error correction techniques were used in this study to estimate the stationarity, and the long-run and short-run dynamics of the research models. The result gotten showed that the long run determinants of economic growth are the agricultural export and output. Salami (2014), analyzed the impact of agricultural export on economic growth in Nigeria using the ARDL approach. The result showed a long-run relationship between agricultural export, exchange rate, and foreign earnings. The variables tested showed a direct effect on the short- and long- run relationships between agricultural export and economic growth. Sanjuán (2015) studied a larger number of nations (forty two underdeveloped countries) to examine the impact of agricultural exports on economic growth in underdeveloped countries using panel co- integration techniques. The result showed an agricultural export elasticity of GDP of 0.09 and non-agricultural export elasticity of GDP of 0.13.

Heckscher – Ohlin Trade Theory

The Heckscher – Ohlin Theorem (H-O model) was developed by Eli Heckscher in 1919, and Bertil Ohlin in 1933 based on the Ricardian comparative advantage. The model is also called 'factor endowment theory' because it stresses that the pattern of production and trade across national borders depends on the domestic factor endowments. Foreign trade takes place due to the differences in the comparative costs of factors of production that arises, due to the abundant or insufficient resources (labour and capital) within countries. Therefore, countries should produce and export products that they have a cheap factor(s) of production and import goods or inputs that are scarce locally (Blaug, 1992).

Research Methodology

Export intensity index compares the share of exports to each country in Nigeria's total exports, with the share of world exports going to that country, and therefore gives a measure of the importance of that country to Nigeria as an export destination. A higher index denotes a

stronger relationship, and an index of one (1) indicates that exports to that country are what would be expected given global trade patterns. The Study was carried out in Nigeria. The country is located in West Africa and is bordered by Cameroon to the south west, Benin to the South West and Niger to the North. The latitude and longitude of Nigeria are 10° North and 8°East respectively. The population according to the 2006 census was projected by NBS to about 167 million in 2015 and 200 million in 2019 at the rate of 2.8% annual growth rate. Nigeria has about 48 percent of cultivable area. The country encompasses a large variety of climatic and ecological zones, enabling the cultivation of many crops and harvesting of natural products, including rubber trees, peanuts, cotton, oil palms and others. Food staple crops are dominated by cassava and yams, followed by sorghum, millet, maize and rice. The data used for this study were obtained mainly from secondary sources, particularly from publication of Central Bank of Nigeria (CBN): CBN Economic and Financial Review Bulletin, CBN Monthly Reports, CBN Annual Reports, and Statements of Account of various years. Data were also sourced from the Publications of the National Bureau of Statistics. The data series of interest covered the period of 2000-2020.

Method of Data Analysis

Data collected were subjected to descriptive statistics, unit root, and co-integration and Error correction test. Descriptive statistics were used to describe the mean of the series, standard deviation, and minimum and maximum variations . Augmented Dickey-Fuller (ADF) test was used to test whether the variables are non-stationary (unit root). Trade Intensity Indices were generated using equation 1 below. The trade intensity index (T) was used to determine whether the value of trade between two countries is greater or not. It is defined as the share of one country's exports going to a partner divided by the share of world exports going to the partner. It is calculated as:

$$TIIntp = \frac{Xnpt/Xnt}{Xwtp/Xwt} \quad - \quad - \quad - \quad - \quad - \quad - \quad (1)$$

Where: - **TIIntp** = is the trade intensity index between Nigeria and its trading partners, **Xntp =** Nigeria's export to Trading Partners, **Xwtp** = World's export to Trading Partners, **Xnt** = Nigeria's total exports, **Xwt =** World's total exports. The trade intensity index can also be divided into export intensity index (EII) and import intensity index (III), which can be calculated as;-

$$EIIntp = \frac{Xnpt/Xnt}{Mtpt/(Mwt-Mnt)} \quad - \quad - \quad - \quad - \quad - \quad (2)$$

Where: - EIIntp = Nigeria's export intensity index with its Trading Partners, Xntp = Nigeria's export to Trading Partners, Xnt = Nigeria's total exports, Mtp = Trading partners total imports, Mwt = World's total imports and Mnt = Nigeria's total imports.

$$NIIntp = \frac{Mnb/Mnt}{Xbt/(Xwt-Xnt)} \quad - \quad - \quad - \quad - \quad - \quad (3)$$

Where: - IIIntp = Nigeria's import intensity with it Trading Partners, Mntp = Nigeria's import from its Trading Partners, Mnt = Nigeria's total imports and Xtpt = Trading partners total exports, to estimate long- and short-run impact of agricultural export on agricultural sector growth, different time series data analytical techniques were used. To determine the impact of agricultural exports on economic growth, co-integration and error correction model was used as shown in equation 4. Stationarity of the time series was carried out and tested using unit root test and Augmented Dickey-Fuller (ADF) Ordinary Least Square (OLS) model explicitly stated and used thus;

$$Y = R_{GDPt} = \beta_0 + \beta_1 AEXP_t + \beta_2 IFL_t + \beta_3 ADOt + \beta_4 EXRt + \mu i \ldots\ldots\ldots\ldots\ldots (4)$$

Where: Dependent variable (Y) = Agricultural output growth (i.e Real Gross Domestic Product (GDP)), $_{AEXPt}$ = Agricultural Export (Values of

Agricultural output; measured in Naira), $_{IFLt}$ = Agricultural Degree of Openness. (Measured as ratio of Imports + Exports) to the GDP, $_{ADOt}$ = Exchange Rate (Exchange rate which represents a proxy of exchange rate prices at time t), $_{EXRt}$ = Inflation Rate (inflation rate which represents a proxy of inflation rate prices at time t) and U = error term

Model Specification

The explicit forms of the model are stated below;

$$R_{GDPt} = \beta_0 + \beta_{1AEXPt} + \beta_{2IFLt} + \beta_{3ADOt} + \beta_{4EXRt} + \mu i \quad (4)$$

Where, R_{GDPt} = Real Gross Domestic Product (measured in Percentage %), ADO_t = Agricultural Degree of openness (measured as ratio of Imports + Exports) to the GDP, A_{EXPt} = Agricultural Export (values of Agricultural output; measure in Naira ₦), EXR_t = Exchange rate (Exchange rate which represents a proxy of exchange rate prices at time t), $INFL_t$ = Inflation rate which represents a proxy of inflation rate prices at time t), β_0 = Constant, β_1, β_2 and β_3 = Slope/coefficient, μi = Error term and Subscript t = time. The above equation is represented in logarithmic form to enable the researcher standardize all the values and interpret the variables' coefficients as elasticity. This is shown in the equation below:

$$LnrGDP_t = \beta_{0t} + \beta_1 lnAEXP_t + \beta_2 lnADO_t + \beta_3 lnINFR_t + \beta_4 lnREXR_t + \mu_t \quad - \quad - (5)$$

Unit Roots Test: The unit root test applied in the study in the Augmented Dicker – Fuller (ADF) unit root test is discussed extensively in Dickey and Fuller (1979). This test examines the stationarity of the data series in the data set. It consists of running a regression of the first difference of the series against series lagged once, lagged difference terms and optionally, a constant and a time trend. This can be expressed as:

$$\Delta Y_t = B_t + BY_{t-1} + S\ ai\ \Delta Y_{t-1} + U_t, \quad - \quad - \quad -(6)$$

Where Y_t is the endogenous variable, Δ is a difference operation, U_t, is a deterministic term which may consist of the constant or drift and the trend, B and ai an co-efficient of Y_t -1 and ΔY_t – 1 respectively.

Co-integration Test

Co-intergation test was used to check for long-run relationship among the variables (Agricultural Degree of openness, Agricultural Capital Formation, Agricultural exports and imports price ratio, Real Exchange Rate and Foreign Investment on Agriculture). Thus, the test is deployed as a preliminary test of the stationarity of the data. The essence of this is to prevent spacious regression results.

Results and Discussion

Nigeria had a particularly strong export relationship with USA, with average export intensities of 1.13, 1.49, 1.56 and 0.64 for 2000-2005, 2006-2011, 2012-2017, 2018 -2020, with a mean of 1.28 for the period 1990 to 2020, while the highest indices were observed between 2012 and 2017 as presented in Table 1. Germany was also a key export market with intensities of 1.90, 1.52, 2.73 and 1.73, with a mean of 2.00 during the same period despite more exports to Germany than other industrial nations. This was due to certain trade agreements and probably favourable macroeconomic policies that supported export growth in the country and Germany was one of the major global markets. France and United Kingdom were the other two largest export destinations, and recorded intensities of 2.71, 2.20, 2.58 and 1.98, with a mean of 2.42 for France, and 1.68, 1.77, 1.64 and 1.28 with mean of 1.63 for the United Kingdom

Nigeria's major trading partners in terms of import among the industrial countries were United States, France, Germany and United Kingdom. During the period, on average, the import intensity of Nigeria with USA was 0.74, with a highest index of 2.05 observed between 2018 and 2020. The import intensity of Nigeria with United Kingdom was 2.23, higher index of 2.23 was derived between 2018 and 2020. Also, Nigeria's import intensity with Germany was

very high, with an explosive value of 3.62. Highest and explosive indices of 7.03 were observed between 2018 and 2020. These explosive values show that Nigeria's importation position from Germany is quite higher than expectation and revealed that, high intensity reflects a very high dependent on importation of agricultural and non-agricultural produce from Germany. It further revealed that, Germany's exports to Nigeria reflect the global share of imports accounted for by Nigeria. By contrast, France showed high import intensities (average, 3.10) with Nigeria between 2012 and2017 denoting a stronger relationship (Figure 2). The country's import intensities were high with Germany (3.62) and France (3.10) during the period reviewed. However, the import intensity of Nigeria with United States was lower, with a mean index of less than one despite a recorded maximum value of 4.10 as presented in the table below. Across the trading partners , the maximum import intensities was far higher beteween Nigeria and other importing countries of USA, France, Germany and the United Kingdom. This implies that, Nigeria mostly imported from these countries and Nigeria became the major market for their products and services. The trend representation of the intensity indices are presented in Figures 2 and Table 1:

Table 1: Nigeria Agricultural Export and Import Intensities with Industrial Countries

	Export Indices				Import Indices			
Years	**USA**	**France**	**Germany**	**United Kingdom**	**USA**	**France**	**Germany**	**United Kingdom**
2000-2005	1.13	2.71	1.90	1.68	0.81	2.01	4.07	1.28
2006-2011	1.49	2.20	1.52	1.77	0.35	3.26	3.68	3.31
2012-2017	1.56	2.58	2.73	1.64	0.40	5.56	1.41	1.50
2018 -2020	0.64	1.98	1.73	1.28	2.05	0.07	7.03	3.42
Mean	***1.28***	***2.42***	***2.00***	***1.63***	***0.74***	***3.10***	***3.62***	***2.23***
Minimum	***0.12***	***1.03***	***1.2***	***0.70***	***0.09***	***0.05***	***1.12***	***0.07***
Maximum	***2.23***	***4.30***	***4.2***	***3.23***	***4.10***	***9.79***	***16.88***	***10.32***

Source: Author's Computation from CBN's Various Issues. 2023

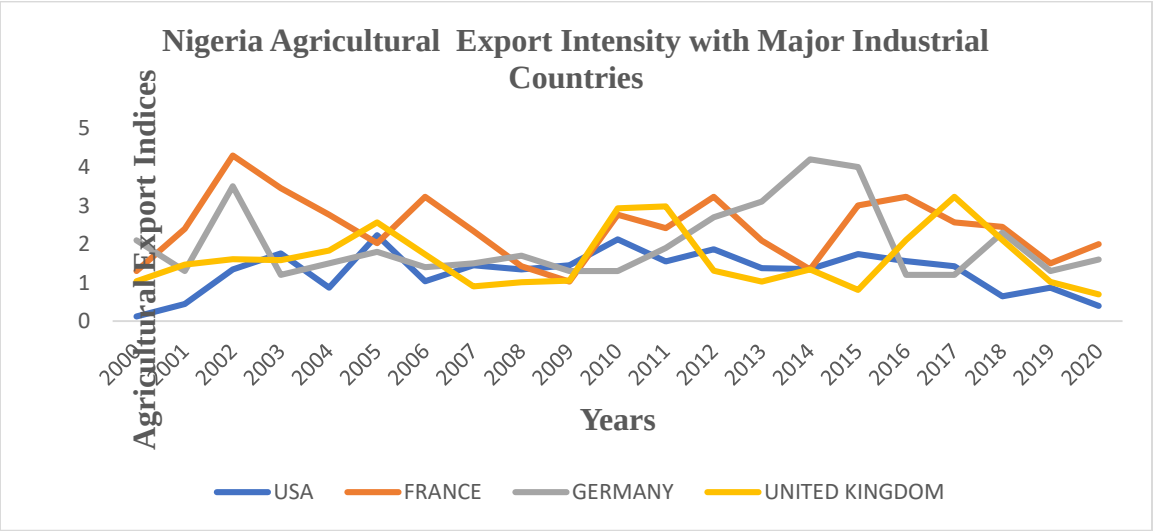


Fig. 2a: Nigeria Agricultural Export Intensity with Major Industrial Countries

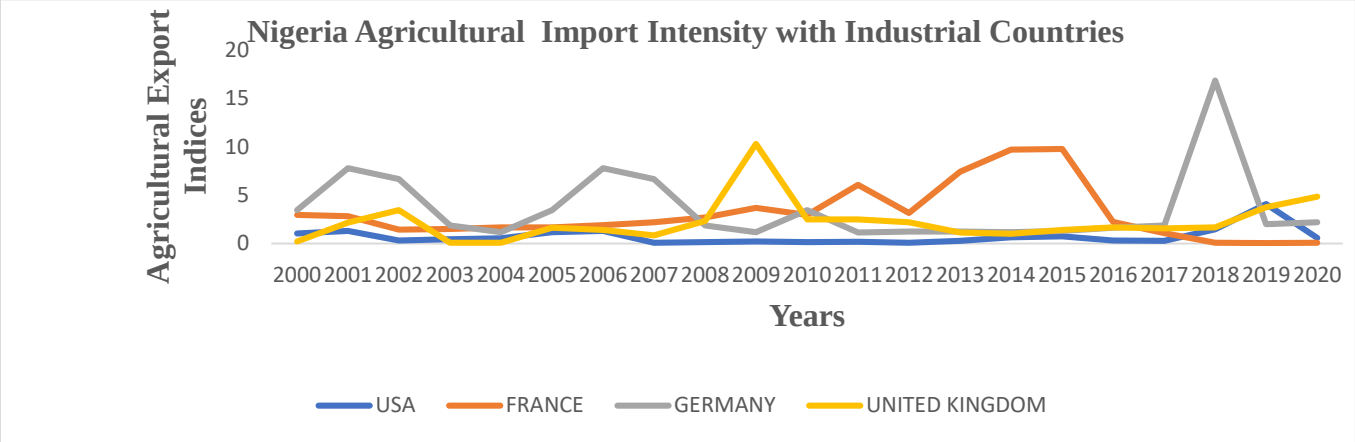


Fig. 2b: Nigeria Agricultural Import Intensity with Major Industrial Countries
Source: Author's Computation from CBN's Report, 2022

Table 2: Augmented Dickey Fuller (ADF) unit root tests for stationary of the variables in the models

Variable	Levels			1st Difference			Decision
	Constant	Constant and Trend	Without Constant and Trend	Constant	Constant and Trend	Without Constant and Trend	
rGDP	-3.9955***	-4.131***	-0.2743	-6.7269***	-65723**	-6.8215***	1(1)
INFL	-2.1155	-0.2540	8-0.228	-5.7752***	-3.9435**	-5.8510***	1(1)
EXR	2.2502	-0.4059	1.2794	-1.0237	-10.4894***	-0.5093	1(0)
AGEXP	-2.0440	-3.0845	-1.1899	-3.9581***	-3.5314*	-4.0500***	1(1)
ADO	-1.4639	-3.1248	0.5386	-3.1279***	-2.7199**	-3.7313***	1(1)

*Source: Author's Computation from E-Views 8.0 Note: ***, **, * denotes rejection of the null hypothesis at 1%, 5% and 10% levels respectively*.

Determination of the Relationship Between Agricultural Export and Economic Growth in Nigeria Unit Root Test

The ADF test shows series that contain a unit root for the null hypothesis against the alternative that do not. The result presented in Table 2 shows that, at levels (1(0)) both intercept and no-trend and intercept with trend showed that, null hypothesis of no unit root cannot be rejected at the both 10 percent and 5 percent levels of significance except in the case of real gross domestic product (rGDP) that was found to be integrated of the order 1(0). At first difference however, all the series became stationary. That is, they were found to be integrated of order 1(1) (both with intercept and no trend and with trend and intercept). Thus, it was concluded that the variables are 1(1) processes

Determinants of Agricultural Trade Intensity in Nigeria

The coefficient of multiple determination (R^2) value of 0.54 as shown in Table 3 indicates that about 54% of the variation in the dependent variable was explained by the independent variables (predictors) included in the model, while the remaining 46% was due to other factors not specified in the model. F-ratio with 2.074 value in the regression result is significant at 1% level. It implies that all the variables have significant or joint effect on the dependent variables. From Table 2, the independent variables such as agricultural export (AGREXP), agricultural degree of openness (ADO), and real exchange rate (REXR) have positive coefficients. This implies that, continuous increase of these variables might have been responsible for increased responses to

agricultural trade intensities in Nigeria over the years. The coefficient of agricultural degree of openness (0.1843) was positive and significant. This implies that, a unit increase on ADO may lead to 0.18 percent increase in agricultural trade intensity. The coefficient of agricultural export (0.2513) was positive and significant at 1%, this implies that a unit increase in agricultural export will contribute 0.25 percent increase in economic growth. The coefficient of real exchange rate (-1.4667) was negative and statistically significant, which implies that a unit decrease in the real exchange rate (rEXR) will lead to -1.47 percent decrease in agricultural trade intensity. It implies that a decrease in real exchange rate (rEXR) decreases the Nigeria Agricultural export performance and hence reduces agricultural trade intensity, thereby reducing agricultural sector and economic growth.

Table 3: Determinants of Agricultural Export in a Trade Liberalized Economy

Variable	*Coefficient*	*Std. Error*	*t-ratio*	*p-value*
Constant	0.266413	0.761163	0.3500	0.7309
lnAGREXP	0.251274	0.047098	5.33510	0.0000***
lnrEXR	-1.466718	0.721668	-2.032399	-1.466718**
lnINFL	0.0332043	0.141974	0.2339	0.8180
lnADO	0.184351	0.097203	1.897	0.0761*
		Diagnostic Statistic		
Mean dependent var.	1.852175	S.D. dependent var.	0.251078	
Sum squared resid	0.830170	S.E. of regression	0.227784	
R-squared	0.541554	Adjusted R-squared	0.516942	
F(4, 16)	2.074909	P-value(F)	0.001872	
Log-likelihood	4.124089	Akaike criterion	1.751822	
Schwarz criterion	6.974434	Hannan-Quinn	2.885263	

***Source: Author's Computation from E-Views 8.0. Note: ***, **, and *denote significant at 1, 5, and 10 percent levels, respectively*.**

Conclusion and Recommendations

In order to promote agricultural export performance in Nigeria, certain policies and agreements to liberalized trade in the country have to be regulated in line with the current economic situations, and such policies have to be sustained in the longrun. Nigeria's trade with major trading partners has recorded a significant increased from 2000-2021 despite the major declined. In spite of the recent decline in trade, bilateral trade between countries has recorded a remarkable growth especially from 2001 to2011. The result shows that Agricultural export (AGREXP), agricultural degree of openness (ADO), and real exchange rate (REXR) have positive coefficients, meaning that the more of these variables, the more response to agricultural trade intensity. Regulating these macro-economic variables will promote agricultural export performance hence, agricultural trade intensity. The study therefore recommend that government should encourage export and promote bilateral trade between the countries, because both countries are characterized by large markets, teaming and growing population. Trade policies should be regulated to encourage domestic production, which in turn could increase export, hence increased trade intensity.

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The Viability Of Aquaculture Cum Agriculture Integration In Diversification Of Economy In Nigeria

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Abstract: *This paper discusses aquaculture cum agriculture integration and its viability in diversification of the economy of Nigeria. Aquaculture cum Agriculture Integration is an eco-friendly production system that comprises of three components: garden, pond, and livestock pen which are carried out concurrently on the same piece of land. It can be broadly classified into two, namely: Crop-fish and Livestock-fish systems. Although Nigeria is one of the largest oil producers in the world, agriculture remains the foundation of the economy, providing the main source of livelihood for most Nigerians. Aquaculture in Nigeria is increasingly becoming popular because of the demand for healthy animal protein and its profitability. The good thing about aquaculture business is that it is not seasonal like other types of farming. Therefore, its viability in integration with crop and livestock production for economic diversification cannot be in doubt. Fisheries and aquaculture make up 3–4 percent of Nigeria's annual GDP. The sector is also a key contributor to fulfilling the population's nutritional requirements, accounting for about 50 percent of the supply of animal-source food, and it is an important source of essential dietary nutrients. Agriculture contributes over one quarter of the GDP in the most developing nations of the world, especially in Nigeria. Nigeria's agricultural sector contributes to a significant part of the country's GDP. Between July and September 2021, agriculture contributed to almost 30 percent of the total GDP, an increase by about six percentage point compared to the previous quarter. Integrated aquaculture production system is not well developed in Africa. Egypt was the starter of traditional aquaculture production system while the modern one was started in Kenya. Aquaculture Agriculture Integration needs to be developed for sophistication and intensification in Nigeria, to boost her economic diversification.*

Keywords: Aquaculture, Agriculture, Integration, Diversification of Economy, Nigeria

CITATION:

Ndaeyo, N. U., Akpabio, I. A., Udom, G. N. and Oribhabor, B. J. (2023). The Viability of Aquaculture Cum Agriculture Integration in Diversification of Economy in Nigeria. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 585-590

Introduction

Aquaculture cum Agriculture Integration is an eco-friendly production system that comprises of three components: garden, pond, and livestock pen which are carried out concurrently on the same piece of land. They efficiently use all the available land, air, water, and solar energy resources while also effectively recycling the by-products, as well as waste. This provides a diversity of agricultural products that meet the complex nutritional demands of rural communities. Many studies have proved that aquaculture cum agriculture systems are very efficient and effective at ensuring food security as well as economic development of rural communities (Van Huong *et al*., 2018).

Aquaculture cum agriculture integration could be called agriculture aquaculture integration or integrated fish farming. Integrated fish farming is more profitable than unitary system of farming as it ensures a spread of financial risk for its varied and diversified nature in rearing of fish, animals and crops; it has a capacity of making more food available thus enhancing food security and creating more jobs. Before this potential can be fully realized, its ecological importance must be taken into consideration, as this will dictate the pace for effective management that will lead to its maximum yield (Gebru, 2021).

The Nigerian economy was dominated by commercial activities and exports prior to independence in 1960 as there was no viable industrial sector. Gaining independence, agricultural activities served as the pivot around the sustenance of the Nigerian economy. Agriculture showed its efficacy by contributing to the GDP by 65% despite the swings in world prices (Jide, 2017). Thus, it was through Agriculture that revenues were raised that facilitated the importation of capital goods and raw materials from foreign nations through international trade. Sufficient food was produced by peasant farmers which were enough not only for domestic consumption but for export as well. Post-civil war, there was a switch in the export structure as activities migrated from agriculture-based to oil-based, implying a gross and significant reduction in the contribution of the agricultural sector to the economy (Olaleye *et al*., 2013). The ensuing problems far outweighed the benefits. Oil exploration led to environmental degradation and devastation in the Niger Delta region, oil wealth also demobilized the Nigerian people. The agricultural (which once was the bedrock and pivot around which other sectors rallied) began attracting lesser government attention, thereby leading to its neglect. Local production of goods and services plummeted; rapid urbanization led to slum development and crime. Massive importation and consumption of foreign goods turned Nigeria into a huge market for foreign producers. This led to massive unemployment, underemployment and poverty rates which are worsened by population explosion. The mismanagement of the agricultural sector coupled infrastructural problems saw a decline in the Nigerian export prowess of cash crops (e.g., groundnut, cashew, cocoa, timber, oil palm, rubber, among others). Economic diversification has been the clamour of successive administrations in Nigeria, especially amidst the dwindling oil-revenue in recent years, which has resulted from the fluctuations in world crude oil prices. This is due to the fact that it has the capacity to identify and unleash the inherent potentials in the other sectors of the economy yet untapped, aside from the oil sector. Economic diversification has been argued to be critical in achieving sustainable and stable growth of the Nigerian economy (Owan *et al*., 2020).

Nigeria has the benefit of having large stretches of fertile land available to cultivate. This country has one of the largest expanses of land in Africa with more than 900 thousand square kilometers. This land provides Nigeria with practically an unlimited source of farming for food, providing agricultural produces and jobs for the people. To achieve sustainable growth and development, Nigeria must mobilize massive local financing and create transparent institutions that encourage large-scale investments in agriculture, manufacturing, education, healthcare and training of its population. This paper discusses aquaculture cum agriculture integration and its viability in diversification of the economy of Nigeria.

Aquaculture Agriculture Integration Systems

Aquaculture Agriculture Integration can be broadly classified into two, namely: Crop-fish and Livestock-fish systems (FAO, 2001, Melaku and Natarajan, 2019). Crop-fish systems include rice-fish integration, horticulture-fish system, mushroom-fish system, Seri-fish system. Livestock-fish system includes cattle-fish system, pig-fish system, poultry-fish system, duck-fish system, goat-fish system, rabbit-fish system. Figure 1 below depicts fish-livestock-crop integration (Gebru, 2021).

Crop-fish systems

The integration of aquaculture and agriculture is traditional and diverse in the world but rice-fish farming is the most common and oldest practice. It consists in raising rice and fish together in the same irrigated field to obtain a fish crop in addition to the rice which remains the main production (Halwart and Gupta, 2004). Fish feed on the rice midge larvae, pest and other undesirable organisms on rice. Their excreta provide fertilization and their bioturbation behavior increases the nutrients (such as nitrogen and phosphorus) availability for plants. Potential fin fish species which can be reared in rice fields ought to be species which are accustomed to low dissolved oxygen levels, high water turbidity, surface water and higher temperatures. According to FAO (2001), finfish species such as *Clarious batrachus, Clarias macrocephalus, Anabas testudineus, Mugil species, Catla catla, Cirrhina mrigala, Labeo rohita, Cyprinus carpio, Oreochromis mossambicus, Lates calcarifer, Channa striatus, Chanos chanos* and *Channa marulius* have been cultured along with the rice fields. Often in some countries integration of crop - livestock - fish systems is being practiced in which livestock wastes are directed to fish ponds where the wastes fertilize the pond water. Subsequently the fertilized pond effluent is used to irrigate the nearby crop fields (Melaku and Natarajan, 2019).

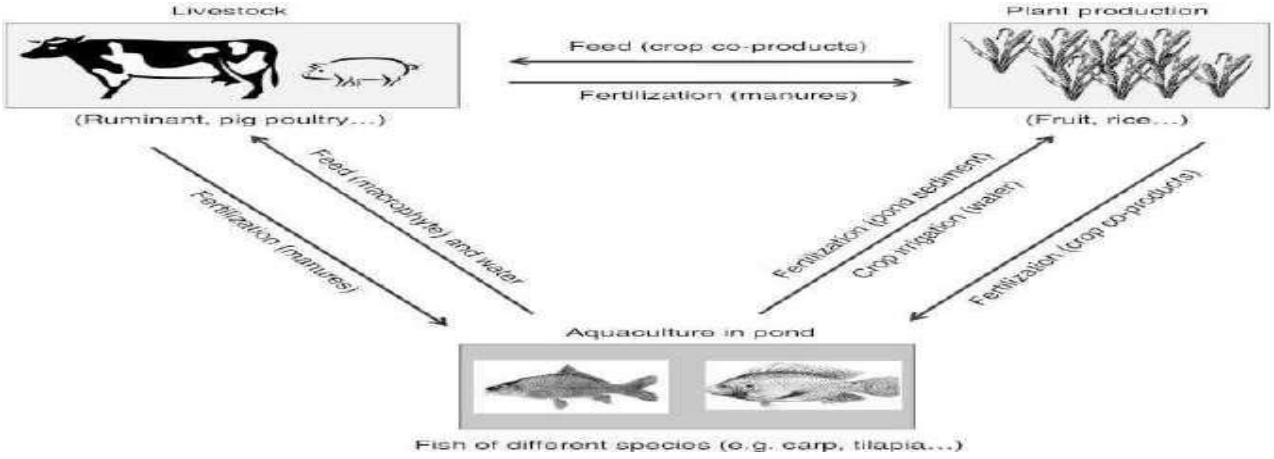

Fig. 1 fish-livestock-crop integration (Gebru, 2021).

Live-stock fish systems

By combining livestock such as cattle, pig or poultry with fish, animal excreta and waste food serve to stimulate water productivity, natural feed production and fish growth, as well as delivering other symbiotic benefits for both animals (Barash *et al*., 1982).

Contributions of Aquaculture and Agriculture to the Economy of Nigeria

Although Nigeria is one of the largest oil producers in the world, agriculture remains the foundation of the economy, providing the main

source of livelihood for most Nigerians. The sector faces many challenges that constrain agricultural productivity (average of 1.2 t of cereals/ha), with high post-harvest losses and waste (FAO 2016). Livestock is an important component of Nigerian agriculture. However, domestic production of livestock products, except for eggs, is far below demand, resulting in large imports of livestock and livestock products. The livestock sector has the potential to create new opportunities for farmers and provide more affordable and healthier diets for future generations (FAO 2016).

Fisheries and aquaculture make up 3–4 percent of Nigeria's annual GDP. The sector is also a key contributor to fulfilling the population's nutritional requirements, accounting for about 50 percent of the supply of animal-source food, and it is an important source of essential dietary nutrients. In addition, fisheries, aquaculture and associated value chains generate employment and income for a significant number of fishers, fish farmers and fish traders. Yet despite the potential for fish production through aquaculture, artisanal and inland fisheries, domestic fish production still falls far below demand. As a result, the country imports half of the fish it consumes. To reduce the level of fish imports and decrease the drain on foreign exchange, the Government of Nigeria has selected aquaculture as one of the priority food value chains targeted for expansion and development (Subasinghe *et al*., 2021).

Agriculture is known to be an extended age practice in the third world and developing nations. The importance of agricultural development to socio-economic growth and development in many third world countries is keen on their transition to economic prosperity. Agriculture contributes over one quarter of the GDP in the most developing nations of the world, especially in Nigeria (Sertoğlu *et al*., 2017). Nigeria's agricultural sector contributes to a significant part of the country's GDP. Between July and September 2021, the agriculture contributed to almost 30 percent of the total GDP, an increase by about six percentage point compared to the previous quarter. Agriculture is a key activity for Nigeria's economy after oil. Nevertheless, agricultural activities provide livelihood for many Nigerians, whereas the wealth generated by oil reach a restricted share of people. Shown below is the contribution of agriculture to GDP in Nigeria from 2019-2021(Table 1).

Table 1: Contribution of agriculture to GDP in Nigeria from the 3rd quarter of 2019 to the 3rd quarter of 2021 (Sasu, 2023).

Characteristic	Share of GDP
Q3 2021	29.94%
Q2 2021	23.78%
Q1 2021	22.35%
Q4 2020	26.95%
Q3 2020	30.77%
Q2 2020	24.65%
Q1 2020	21.96%
Q4 2019	26.09%
Q3 2019	29.25%

Benefits of Aquaculture Agriculture Integration Systems

The population of people living in Nigeria has risen tremendously in recent years with its corresponding increase in demand for food. Thus, there is the need for a suitable agricultural system to meet this increasing demand and also maximize the utilization of the available limited resources without much wastage. Aquaculture Agriculture Integration offers hope in this direction. This system of farming was introduced into the country some years back. Its uniqueness lies in the fact that it has capability of combining fish culture with live stock and crop production. It is of economic benefit in the enhancement of food production and self sufficiency. Its significance in making various types of food available all the year round as well as making

farmers self reliant and occupied most time of the year sets it apart from all other systems of farming. It is ecological importance in manure loading, nutrient cycling and productive capacity of ponds. This ecological consideration is of paramount importance in that it allows recycling, and maximum utilization of resources without wastage (Gabriel *et al*., 2007).

Agriculture has been regarded in recent times as the most viable route with which Nigeria can successfully meander from her current economic dilemma. Agriculture involves the science, practice and occupation of cultivating land and raising crops. It also involves the feeding, breeding and raising of livestock. The main purpose of agriculture is to provide food and raw materials for human use. Agriculture serves in massive employment of labour in Nigeria, foreign exchange earner, food security and provision of raw materials to support industries. With the current dwindling of crude oil prices in the international market, agriculture seems to be the most sustainable way forward for diversification of Nigeria Economy (InfoGuide Nigeria, 2018).

The Need for Sophistication and Intensification of Aquaculture Agriculture Integration in Nigeria

The integration of aquaculture with livestock or crop farming provides quality protein food, resource utilisation, recycling of farm waste, employment generation and economic development. Integrated aquaculture system is implemented in different parts of the world and it has very long history with an aim of improving fish production, minimizing fish production costs, environmental protection from pollution and waste management and increasing income, generating fish feed from waste materials (Prein, 2002). Integrated fish farming is well developed culture practice in China followed by Hungary, Germany and Malaysia. The integrated fish farming is accepted as a sustainable form of aquaculture. For integration we can use recycled effluents from Agro-based industries as well as food processing plants.

Integrated aquaculture production system is not well developed in Africa. Egypt was the starter of traditional aquaculture production system while the modern one was started in Kenya. Some progress on integrated aquaculture agriculture systems has been reported in a few African countries such as vegetable fish farming in Ghana and Malawi (Gebru, 2021). In east Africa fish farming is practiced for nutritional needs and to some extent for income generation (Shoko., 2011).

Aquaculture Agriculture Integration needs to be developed for sophistication and intensification in Nigeria, to boost her economic diversification. It needs continuous research to improve the productivity of the complete integrated system focusing on maximizing the fish yield through efficient utilization of Livestock manure for fish ponds in order to minimize fish feed problems (Endebu *et al*., 2016).

Conclusion

Aquaculture in Nigeria is increasingly becoming popular because of the demand for healthy animal protein and its profitability. The good thing about aquaculture business is that it is not seasonal like other types of farming. Therefore, its viability in integration with crop and livestock production for economic diversification cannot be in doubt. Integrated culture is not new and exists naturally. The natural ecosystem itself is a big example for integrated culturing where a number of flora live together in the same area of land. In recent years, the government of Nigeria has put forth policies to promote agriculture in the country. Although a lot has been achieved in the area of food security, a lot still has to be done. If the proper investments are made in the agricultural sector, the current contributions being made to the economy by this sector can be doubled or even tripled because Nigeria has

both human and natural resources to achieve this potential. Nigeria currently has a very high youth unemployment rate and this is beginning to result in a security threat in the country. Aquaculture Agriculture Integration has a high potential to rescue Nigeria from this quagmire. It is a common saying that the quality of food consumed by a people is a stark revelation of the quality of life of the people. With a population of over 200 million, Nigeria needs to produce enough food to cater for her growing population and also export to earn foreign exchange.

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Entrepreneurial Skills Development And Survival Of Small-Scale Businesses In Akwa Ibom State

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Abstract: *The main purpose of the study was to determine the extent to which entrepreneurial skills development influence survival of small scale businesses in Akwa Ibom State. To guide the study, three specific objectives and three research questions were raised, while three hypotheses were formulated. Descriptive survey research design was adopted. The population of the study was 1232 registered small scale businesses from the thirty-one Local Government Areas in Akwa Ibom State. The sample of the study was 302 managers of small scale businesses. A structured questionnaire tagged "Entrepreneurial Skills Development and Survival Small Scale Businesses Questionnaire (ESDSSSBQ)." The instrument was given to three subject experts in Business Education Department, University of Uyo, Akwa Ibom State for face validation. The Cronbach Alpha reliability index of 0.89 was obtained for the instrument. The data collected were analysed using Mean scores to answer the research questions, while related t-test was used to test the hypotheses at 0.05 level of significance. The findings of the study revealed that, the extent to which managerial skills, marketing skills and accounting skills influence survival of small scale enterprises in Akwa Ibom State is significant. It is therefore recommended that small business owner should undertake entrepreneurial skill acquisition programme in order to enhance their capacity to manage small scale businesses.*

Keywords: Entrepreneurial Skill Development**,** Managerial skills, Marketing skills, Accounting skills, Small Scale Businesses

CITATION:
Usoro, E. B., Asuquo, E. E. and Eminue, U. O. (2023). Entrepreneurial Skills Development and Survival of Small-Scale Businesses in Akwa Ibom State. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Professor Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 575-584

Introduction

In every society, business of any size or form is considered as an enterprising entity or an organized effort geared towards the creation of goods and services to the people, with the ultimate aim of making profit. It is important that a business makes profit for its continuous survival and growth. Small scale business like any other form of business cannot survive, if the befits derived from goods and services provided to the people are not more than the cost of doing such business. Hence, profit making positively correlate with survival, growth and sustainability of business, be it small, medium or large scale. Profitability and survival of businesses, especially small scale businesses depend on many factors, such as amount of start-up capital, business environment, micro and macroeconomic policies and skills of the entrepreneur, among others. However, no matter the amount capital available or how well the business environment, if entrepreneurial skill is lacking, it may be difficult, if not impossible for small scale business to survive due to competition. Therefore, to have a

niche in the market share, small scale business owners need to develop entrepreneurial skills for survival, or otherwise face the risk of extinction.

In Nigeria, small scale businesses are defined by different authors in terms of ownership, capital formation and number of employees. For instance, Nigerian Bank of Commerce and Industry cited in Etifit, Eminue and Udoh (2016) defined a small scale business enterprise as one whose capital does not exceed seven hundred and fifty thousand naira (₦750, 000). Central Bank of Nigeria (2011), defined small scale business enterprise as an enterprise whose annual turnover ranges between (₦25,000 – (₦50,000, whose capital is less than ₦1.0million and number of employees is less than 50 persons. According to Ugwunwoti and Ezugwu (2017), a small scale business enterprise is one which is independently owned, financed and controlled by private individuals. In most cases, small scale businesses are managed by the owners who enjoyed all the benefits and bear all the risks. Small scale businesses represent the greatest percentage of business activities all over the world. They are essential to economic growth and development of any nation, as well as playing a dominant role in socioeconomic well-being of the people. The sector provides great potentials for employment creation, income generation, improvement of local technology and output diversification.

In recognition of this role, the Federal Government of Nigeria has attempted to provide an enabling environment like establishment of microfinance banks and establishment of agencies and programmes for small scale businesses to survive. There is also laws and regulations to ensure ease of doing business in Nigeria. Many States of the federation such as Lagos, Kano, Kaduna, Abia, Anambra and Enugu appear to turn their major cities into commercial hub, where small scale businesses are flourishing. However, the case in Akwa Ibom State seems to be different as many small scale businesses are experiencing business stagnation, stunted growth and winding up within a short period of their operation. Could this be as a result of lack of entrepreneurial skills? It is obvious that no business can survive and grow without application of the necessary innovative skills needed for the operation of the business. Hence, the need for this study to determine the extent of influence of entrepreneurial skills on survival of small scale businesses in Akwa Ibom State, Nigeria

The awareness of the need for entrepreneurial skill in order to stimulate entrepreneurial activity and reduce business failure have been increased among stakeholders in the industry, business and government of many countries because entrepreneurs could be born or made (Ikegwu, Ajiboye, Aromolaran, Ayodeji & Okorafor, 2014). Newlands (2014) maintained that entrepreneurial skills are general ability needed to perform professionally within an organisation. These are skills needed to start, develop and improve an enterprise or organisation so as to succeed in its day to day operations or activities. Jain (2013) described entrepreneurship as behaviour, attitude and an approach to the way people create new values in the market, technology consumption, habits and build sustainable institutions and organizations. Entrepreneurial skills development is a process whereby a person acquires or learns a particular skill or type of behaviour needed for business through training or education (Amadi, 2012). These skills can be obtained through formal education, such as entrepreneurship education in the curriculum of Business Education and related fields in tertiary institutions in Nigeria. Entrepreneurial skills development can also take place informally, through skills acquisition programmes, apprenticeship, seminars and workshop organised for that purpose for graduates and artisans to improve their skills. These skills are indispensable for survival of small

scale businesses both for profitability, growth and sustainability. Such skills include but not limited to and managerial, marketing and accounting skills.

Young and Tiller (2016) defined managerial skills as entrepreneurial capability to generate and generalize ideas that impact multiple frontiers and business practices, by means of specific business administration initiatives. This capability is composed of three fundamental parts: First is acquiring, discovering, creating and promoting ideas; second is sharing ideas internally in the enterprise and third is detecting and correcting problems that may lead to failures in the two previous parts. Money and Odibo (2015) opined that entrepreneurs must be able to manage every component of a business. Even if entrepreneurs hire managers to attend to daily details, they must understand if their business has the right resources and if those resources are being used effectively. For survival of small scale businesses entrepreneurs must acquire managerial skills needed in planning and organising business activities in an effective and efficient manner.

Marketing skills is another important and essential skill which determines the success or failure of a business. Marketing is a common phenomenon but it is a very complex and elusive subject matter. Marketing is crucial to the success of any entrepreneurial effort. Money and Odibo (2015) reported that a business' success or failure is very dependent on whether the business reaches the market (its potential customers). Development of marketing skills is very important for the survival of small scale business. This implies that Business education could promote entrepreneurship through making students to properly perform their entrepreneurial functions. Ademiluyi (2013) opined that the acquisition of marketing skills offers the entrepreneur the unique strategy for succeeding in business. Development of marketing skills would help entrepreneurs to make good use of the 4Ps of marketing namely; product, price, place and promotion. It will also enhance survival of small scale business by ensuring proper pricing of the product, making it available at the right place and time as well as using the right promotional technique(s) to stimulate customers' patronage.

Accounting skills are those competencies in basic accounting required by a person to function competently, confidently and successfully in the process of carrying out one's function of recording daily business transactions (Onoh, 2011). They include skills in book-keeping, purchasing and supply, bargaining, determining costs, simple budgeting, keeping of accurate receipts, sales records skills in keeping reliable records, sourcing for market outlets, work in progress records, credit purchases, invoices, cheque payments, keeping customers' records and goods inventory. Ademola, *et al.,* (2013) explained that keeping proper books of accounts is essential to the growth and survival of a business. Poor records keeping or non-availability of financial records will lead to resources mismanagement and poor cash management and this can cause the business to fail. Dawuda and Azeko (2015) asserted that poor or lack of records keeping by small scale businesses would not only limit the ability to accurately and reliably measure the financial performance and position, but also affect other users such as customers, suppliers and financial institutions, among others. Accounting skills promote good financial management, ensure there is adequate cash at hand to meet the necessary current and capital expenditures as well as to assist in maximising growth and profits.

Ukoima and Eminue (2022) conducted a study on business plan development skills needs for capital accessibility by small business owners in Oron Local Government Area. The result indicated that small business owners need more

training on marketing research and financial forecasting skills for access to capital. Etifit *et al.,* (2016) conducted a study on information and communication technology (ICT) and accounting skills required for the establishment of small scale enterprises by entrepreneurs in College of Education, Afaha Nsit, Akwa Ibom State. The result of the findings revealed that ICT and Accounting skills are highly required for establishment of small scale enterprise by both female and male students of Business Education upon graduation. Money and Odibo (2015) conducted a study on Nigerian small and medium enterprises (SMEs) management: An effect of entrepreneurial skills. The study was conducted in Warri and Effurun, Delta State. The result revealed that there is direct significant in the application of entrepreneurship skills to the success and positive development of SME's

Statement of the Problem

Despite the prospect of small scale businesses as the catalyst of economic growth and development, failures in recent times is becoming so pronounced. The failure of many small scale businesses seems not to arise because the owners/managers do not have the necessary capital to stay afloat or because there is no enabling business environment, but because of lack of prerequisite skills needed to grow and sustain the business. It is presumed that most entrepreneurs are not fully equipped with the relevant skills for survival of small scale businesses because of poor managerial skills. Wrong decision making, lack of innovation and poor planning has posed a great threat to the survival of small scale businesses in Akwa Ibom State.

Lack of marketing skills is also one of the major setbacks to many entrepreneurs. It seems the entrepreneurs are not able to offer the right product to the targeted customers at the right prices and at the right time. Lack of marketing skill lowers the rate of turnover and increases overhead cost. Inability to keep proper books of accounts also affect survival of small scale businesses. The resultant effects are imminent, such as business failure, increase in the rate of unemployment and poverty, leading to restiveness, kidnapping, as well as low Gross Domestic Product (GDP), low per capita income and economic underdevelopment. The problem therefore is, can entrepreneurial skills development influence survival of small scale businesses? The desire to unravel solution to this problem necessitated this study on entrepreneurial skills development and survival of small scale businesses in Akwa Ibom State.

Purpose of the Study

The main purpose of the study was to determine the extent to which entrepreneurial skills development influence survival of small scale businesses in Akwa Ibom State. The study specifically sought to:

i. determine the extent to which managerial skills development influence survival of small scale businesses in Akwa Ibom State.
ii. determine the extent to which marketing skills development influence survival of small scale businesses in Akwa Ibom State.
iii. determine the extent to which accounting skills development influence survival of small scale businesses in Akwa Ibom State.

Research Questions

i. What is the extent to which managerial skills development influence survival of small scale businesses in Akwa Ibom State?
ii. What is the extent to which marketing skills development influence survival of small scale businesses in Akwa Ibom State?
iii. What is the extent to which accounting skills development influence survival of small scale businesses in Akwa Ibom State?

Research Hypotheses

H_{O1}: The extent to which managerial skills development influence survival of small

scale businesses in Akwa Ibom State is not significant.

H_{O2}: The extent to which marketing skills development influence survival of small scale businesses in Akwa Ibom State is not significant.

H_{O3}: The extent to which accounting skills development influence survival of small scale businesses in Akwa Ibom State is not significant.

Methodology

Descriptive survey design was adopted for the study. The design enables the researcher to collect, organise, analyse and describe data from a sample of population using a questionnaire. The study was conducted in Akwa Ibom State. The State was created on 23rd September 1987 and has 31 Local Government Areas with Uyo as the State capital. The population of Akwa Ibom State is 3,902,051 persons and a landmass of 7,245,935km (Federal Republic of Nigeria [FRN], 2007). Geographically, the state is a core Niger Delta State in the south-south geopolitical zone. The State lies between latitudes $4^0 32^1$ and $5^0 33^1$ North and longitudes $7^0 25^1$ and $8^0 25^1$ East of the Equator, and is bounded in the North West by Abia State, on the south west by Rivers State, on the east by Cross River State and on the south by Atlantic Ocean (Bight of Bonny). Akwa Ibom State is currently the highest oil producing state in Nigeria and has international airport, proposed site for sea port, ultra-modern world class stadium, sound e-library, several tourist centres and government institutions which can support small scale businesses if entrepreneurial skills are developed. The population of the study was 1232 registered small scale businesses from the thirty-one Local Government Areas in Akwa Ibom State. The sample of the study was 302 managers of small scale businesses. This was statistically determined using Taro Yamane formula.

The researcher-developed instrument entitled "Entrepreneurial Skills Development and Survival Small Scale Businesses Questionnaire (ESDSSSBQ)" was used in collecting data for the study. Responses were made on a four-point rating scale as follows: Very Great Extent (VGE) 4 points, Great Extent (GE) 3 points, Little Extent(LE) 2 points and Very Little Extent(VLE)1 point. The instrument was given to three subject experts from the Department of Business Education, University of Uyo, Uyo for face validation. The experts were requested to read through the instrument item by item, make corrections and indicate the suitability of the items. Their comments, suggestions and corrections were included in the instrument and used for the final copy. The reliability of the instrument was determined using item discrimination method. This method permits determination of internal consistency of instrument on a rating scale with multiple options. Cronbach's Alpha statistics was used to obtain the reliability index, which was 0.89. The high reliability index made the instrument suitable for the study. The data collected were analysed using mean score to answer the research questions, while related t-test was used to test all the null hypotheses at 0.05 alpha level. Decision on research questions was based on real value as follows:

Response Options	Values	Real Limit
Very Great Extent (VGE)	4	3.50 – 4.00
Great Extent (GE)	3	2.50 – 3.49
Little Extent (LE)	2	1.50 – 2.49
Very Little Extent (VLE)	1	1.00 – 1.49

In order to test the null hypotheses, the p-value was compared with the level of significance of 0.05. the result was considered significant when the observed *p*-value was less than or equal to 0.05 ($P \leq 0.05$) and H_O was rejected, but when the observed *p*-value exceeded 0.05, t-test was not significant and H_O was retained.

Results

Research Question 1: What is the extent to which managerial skills development influence survival of small scale businesses in Akwa Ibom State?

Table 1: Mean Analysis of managerial skills and survival of small scale businesses in Akwa Ibom State

S/NO	Managerial skills	Mean	SD	Remarks
1	Ability to plan.	3.82	0.54	VGI
2	Ability to coordinate.	3.35	0.64	GI
3	Ability to control.	3.62	0.55	VGI
4	Organizing skills.	3.76	0.66	VGI
5	Ability to establish goals.	3.42	0.57	GI
	Grand mean	**3.59**		**VGI**

VGI = Very Great Influence, GI = Great Influence, Source: (Fieldwork, 2023)

Analysis was conducted to determine the extent to which managerial skills development influence survival of small scale businesses in Akwa Ibom State. Data as presented in Table 1 revealed that the items 1, 3 and 4 had the highest mean ($\bar{x}$= 3.82, 3.62 and 3.76) respectively and the grand mean is 3.59. The Mean scores fall within the real limit of 3.50 – 4.00. This indicated that these items exert very great influence on job performance. The remaining two items had means values of 3.35 and 3.42, and fall within the real limit of 2.50 – 3.49, which indicated great influence. Since three out of five items and grand mean indicated very great influence, it implies that managerial skills have a very great influence on survival of small scale businesses in Akwa Ibom State.

Research Question 2: What is the extent to which marketing skills development influence survival of small scale businesses in Akwa Ibom State?

Table 2: Mean Analysis of marketing skills and survival of small scale businesses in Akwa Ibom State

S/N	Marketing skills	Mean	SD	Remarks
1	Ability to coordinate oneself when customers are pricing products.	3.18	0.48	GI
2	Ability to create awareness of the products through fliers.	3.36	0.48	GI
3	Using right promotional techniques to win customers.	3.50	0.53	VGI
4	Capacity to make the decision on the right products.	3.49	0.50	GI
5	Ability to determine what customers need.	3.57	0.64	VGI
	Grand Mean	**3.42**		**GI**

Note: VGI= Very Great Influence, GI = Great Influence, Source: (Fieldwork, 2023)

Analysis was conducted to determine the influence of marketing skills on survival of small scale businesses in Akwa Ibom State. Data as presented in Table 2 revealed that the items 3 and 5 had the highest mean ($\bar{x}$= 3.50, 3.57) respectively. The Mean scores fall within the real limit of 3.50 – 4.00. This indicated that these items exert very great influence on job performance. The remaining items had mean values ranging between 3.18 and 3.49, and the

grand mean of 3.42 falls within the real limit of 2.50 – 3.49, which indicated great influence. Since three out of five items and grand mean indicated great influence, it implies that marketing skills have great influence on survival of small scale businesses in Akwa Ibom State.

Research Question 3: What is the extent to which accounting skills development influence survival of small scale businesses in Akwa Ibom State?

Table 3: Mean Analysis of accounting skills and survival of small scale businesses in Akwa Ibom State

S/N	Accounting skills	Mean	SD	Remarks
1	Ability to keep timely financial information.	3.33	0.48	GI
2	Keeping proper books of account.	3.49	0.50	GI
3	Ability to keep accurate receipts of the business.	3.46	0.50	GI
4	Ability to keep sales record.	3.18	0.65	GI
5	Ability to keep inventory of goods.	3.09	0.57	GI
	Grand Mean	**3.31**		**GI**

Note: GI = Great Influence, Source: (Fieldwork, 2023)

Analysis was conducted to determine the influence of accounting skills on Survival of small scale businesses in Akwa Ibom State. Data as presented in Table 3 revealed that all the items had means ranging between 3.09 and 3.49 and the grand mean is 3.31. The means fall within the real limit of 2.50 – 3.49, which indicated great influence. This implies that accounting skills have a great influence on survival of small scale businesses in Akwa Ibom State.

Research Hypothesis 1

H_{O1}: The extent to which managerial skills development influence survival of small scale businesses in Akwa Ibom State is not significant.

Table 4: **T-test Analysis of managerial skills and survival of small scale businesses in Akwa Ibom State (n = 302)**

Variables	N	$\overline{X}$	SD	df	t-cal	p< .05	Decision
Managerial skills and Survival of SSB (Grouped)	302	2.95	1.76	301	5.19	.000	Sig

Sig = Significance, Sig @ P≤ .05, (Source, Field Work, 2023)

The result in Table 4 shows that the computed t-value is 5.19 with 301 degrees of freedom as well as the p-value of .000. Since the p-value is less than 0.05 level of significance (p< .05), the null hypothesis which states that the extent to which managerial skills development influence survival of small scale businesses in Akwa Ibom State is not significant is rejected. This implies that the extent to which managerial skills development influence survival of small scale businesses in Akwa Ibom State is significant.

Research Hypothesis 2

H_{O2}: The extent to which marketing skills development influence survival of small scale businesses in Akwa Ibom State is not significant.

Table 5:**T-test Analysis of marketing skills and survival of small scale businesses in Akwa Ibom State (n = 302)**

Variables	N	$\overline{X}$	SD	df	t-cal	P≤ .05	Decision
Marketing skills and Survival of SSB (Grouped)	302	0.75	2.60	301	2.44	.000	Sig

Sig. = Significance, Sig at P≤ .05 (Source, Field Work, 2023

The result in Table 5 shows the computed t-value is 2.44 with 301 degrees of freedom as well as the p-value of .000. Since the p-value is less than 0.05 level of significance (p< .05), the null hypothesis which states that the extent to which marketing skills development influence survival of small scale businesses in Akwa Ibom State is not significant is rejected. This implies that the extent to which marketing skills development influence survival of small scale businesses in Akwa Ibom State is significant.

Research Hypothesis 3

H_{O3}: *The extent to which accounting skills development influence survival of small scale businesses in Akwa Ibom State is not significant.*

Table 6: **T-test Analysis of accounting skills and survival of small scale businesses in** Akwa Ibom State **(n = 302)**

Variables	N	$\overline{X}$	SD	df	t-cal	P≤ .05	Decision
Marketing skills and Survival of SSB (Grouped)	302	1.97	2.04	301	2.08	.000	Sig

Sig = Significance, Sig at P≤ .05 (Source, Field Work, 2023)

The result in Table 6 shows that the computed t-value is 2.08 with 301 degrees of freedom as well as the p-value of .000. Since the p-value is less than 0.05 level of significance (p< .05), the null hypothesis which states that the extent to which accounting skills development influence survival of small scale businesses in Akwa Ibom State is not significant is rejected. This implies that the extent to which accounting skills development influence survival of small scale businesses in Akwa Ibom State is significant.

Discussion

The results of finding revealed that there is a very great extent of influence of managerial skills on survival of small scale enterprises in Akwa Ibom State. Also the t-test analysis indicated that the extent of influence of managerial skills on survival of small scale enterprises in Akwa Ibom State is significant. The result is in line with the finding of Young and Tiller (2006) who viewed managerial skills as entrepreneurial capability to generate and generalize ideas that impact multiple frontiers and business practices, by means of specific business management initiatives. Similarly, the result is supported by the finding of Daudu, et al. (2015) who conducted a study on the impact of managerial skills on Small Scale Businesses (SSBs) performance and growth in Nigeria and found that managerial skills have significant impact on SSBs performance.

The results of finding also revealed that there is a great extent of influence of marketing skills on survival of small scale enterprises in Akwa Ibom

State. Also the t-test analysis indicated that the extent of influence of marketing skills on survival of small scale enterprises in Akwa Ibom State is significant. The result is in line with the finding of Money and Odibo (2015) who reported that a business' success or failure is very dependent on whether the business reaches the market (its potential customers) at the right time. The finding is also supported by the finding of Ademiluyi (2013) who reported that the acquisition of marketing skills such as salesmanship, negotiation, sales record keeping, sales promotion, stock record keeping, pricing, advertising channels, advertising media, consumer behaviour appreciation and transportation offers the entrepreneur the unique strategy for succeeding in business.

In related vein, the results of finding revealed that there is a great extent of influence of accounting skills on survival of small scale enterprises in Akwa Ibom State. Also the t-test analysis indicated that the extent of influence of accounting skills on survival of small scale enterprises in Uyo Local Government Area of Akwa Ibom State is significant. The result of this study is in consonant with the findings of Ademola, et al. (2013) who reported that in order to ensure efficiency, effectiveness and continuing survival of any business organization, management must seek for reliable, relevant, accurate and timely financial information for planning and decision making. This finding is supported by the finding of Rankhumise (2010) who posits that poor book-keeping or non-availability of financial records will lead to resources mismanagement and poor cash management and this can cause the business to fail.

Conclusions

The following conclusions were drawn based on the finding of this study on entrepreneurial skills development and survival of small scale enterprises in Akwa Ibom State. From the findings, it is deduced that development of entrepreneurial skills plays a significant role in the survival of small scale businesses. Therefore, if priority is given to entrepreneurial skill development in Akwa Ibom Sttate, it would significantly help managers and owners of small scale businesses in efficient management of resources, maximization of profit, reliable financial reporting, safeguarding of assets, reduction in inventory shrinkage, reduction in operational cost, easily detection of fraud, as well as ensuring niche in the market share for survival of small scale businesses.

Implications of the Findings

The findings of this study have the following implications on the educational system: The findings suggest and re-emphasize that basic entrepreneurial skills should be utilised in the operation of small scale businesses in Akwa Ibom State. In this way, business owners and managers need to acquire these skills either through formal or informal education.

Recommendations

Based on the findings and conclusion of this study, it was recommended that:

i. Small business owner should undertake entrepreneurial skill acquisition programme in order to enhance their capacity to manage small scale businesses.
ii. Small and Medium Enterprises Development Association of Nigeria should organise seminares and workshops for small business owners and managers to improve their entrpreneurial skills.

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Entrepreneurship In Fish Production For Sustainable Livelihood And Economic Growth In Akwa Ibom State, Nigeria

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Abstract: *Akwa Ibom State is one of the coastal states in Nigeria, known for its diverse and rich fisheries resources such as shrimp locally known as "Obu" fresh fish "Ndeg Iyak", periwinkle "Mfi", Crab "Isobo", Clams "Nkop" and many others. Apart from these fisheries resources, Akwa Ibom State also has a very suitable climate, topography, water and soil type for aquaculture. This paper evaluated the entrepreneurship in fish production as a sustainable source of livelihood and economy booster in Akwa Ibom State and highlighted different areas that can generate income and employment. Different areas of livelihood sustenance through fish production highlighted in this paper include fingerlings production, juvenile production, table size production, broodstock production, ornamental fish production, feed production, setting up of feed mill, and supply of feed ingredients to farmers or feed mill owners. The major strategies used to by fishpreneur to increase business performance include self or personal advertisement, financial commitment and discipline, innovative actions, visionary mindset and new skills. Fish processing business also presents various ways in which income can be generated to boost the economy and sustain livelihood such as smoked fish, barbecue fish, fish suya, fisherman soup, fried fish, smoked fish soup, fish oil, fish glue, fresh fish pepper soup, fresh fish soup, fish pie and fishmeal production. In conclusion, fish production is a reliable source of income generation, employment creation, food and nutrition security, and foreign exchange which can be harnessed to secure livelihood and boost the economy of Akwa Ibom State. It is therefore recommended that indigenes and residents of Akwa Ibom State should utilize the entrepreneurial opportunities in the different value chain of fish production for a sustainable livelihood and economic growth of the State.*

Keywords: Entrepreneurship, Fisheries resources, livelihood sustenance, economic growth, income generation, employment creation

CITATION:

Okoko, A. C. and Eyo, V. O. (2023). Entrepreneurship in Fish Production for Sustainable Livelihood and Economic Growth in Akwa Ibom State, Nigeria. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 553-561

Introduction

Fisheries and aquaculture is a major economic sector, which is estimated to provide direct jobs to over 8.6 million people and indirect employment to about 19.6 million through fish production (WorldFish, 2018). Nigeria is a coastal state with the Atlantic Ocean bordering her in the South and a land mass of 923,766 km^2, with about 1.75 million hectares suitable for aquaculture projects (Ekelemu, 2020). Nigeria being the most populous African country has significantly progressed socioeconomically despite the challenges it has faced over the years (WorldFish, 2020). Despite the rich natural

resources available in Nigeria such as crude oil, agriculture still remains the Nigerian economy's base, providing sustainable livelihood for several Nigerians (WorldFish, 2020). In Africa, Nigeria is among the countries with the highest demand for fish with a population of over 200 million. According to Eriegha *et al*., (2022), there are four main sources of fish supply in Nigeria including aquaculture, artisanal fisheries (from rivers, streams, coastal and brackish waters and inland lakes, dams and rivers), industrial marine fishing, and imported frozen fish. There is a massive gap between local fish supply and demand resulting in supply coming from imports to bridge the gap (Eriegha *et al*., 2022). Fisheries contribution to the Nigerian economy is very significant (Udoh and Okoko, 2014). It is on record that Nigeria spent over N500 billion to import fish in 2021 alone, and the National Bureau of Statistics (NBS) documented that N25.75 billion, N35.53 billion, and N62.4 billion of mackerel fish, herrings and blue whiting species were imported in the first half of 2021. According to World Bank (2023), total fisheries production (metric tons) in Nigeria (Figure 1) was 1044812 metric tons in 2020.

Fig. 1: Total fisheries production (metric tons) in Nigeria (Source: World Bank, 2023)

Akwa Ibom State is one of the coastal states in Nigeria, known for its diverse and rich fisheries resources such as shrimp locally known as "Obu" fresh fish "Ndeg Iyak", periwinkle "Mfi", Crab "Isobo", Clams "Nkop" and many others. Other coastal states include Bayelsa, Cross River, Rivers Lagos, Ondo, Ogun, Delta, and Edo. In Akwa Ibom State, fish continues to be included as a major component in the diet of many Akwa Ibomites, as it is identified as a cheap or low-cost protein source with various nutritional and health benefits. Historical records showed that fish farming began in Nigeria in the early 1940s, and in 1942, there was a lull in fish imports from European countries. In Akwa Ibom State, government demonstration fish farms were established and extension activities in the 1960's and 70's given by these demonstration fish farms at Itu and Opobo boosted and created the awareness process and adoption of the technologies in the early days of aquaculture development in Nigeria (Ajenifuja, 1998).

Entrepreneurship is a crucial economic tool that attracts the attention of researchers, government and Non-Governmental Organizations (NGOs) in developed and developing countries including Nigeria. Several initiatives and efforts have been made by governments and Non-Governmental Organization (NGOs) to sponsor and promote entrepreneurship and contribute to the economic growth and development. Entrepreneurship is an activity which involves the discovery, evaluation and exploitation of opportunities to introduce new goods and services, ways of organising markets, processes and raw material through organising effort that previously had not existed (Shane and Ventaramen, 2000). Entrepreneurship has been described as the main sustenance of the economy because of its capacity enhancing economy productivity and enhancing living standard (Nwachukwu, 2012). Also, entrepreneurship are critical components of economic growth as they account for more than

50 percent of GDP of developing economics (Ehis and Frank, 2013). An entrepreneur is usually characterized by its ability to utilize and combine available resources in a creative manner (Schumpeter 2000). Entrepreneur in fisheries is known as fishpreneur while Entrepreneur in aquaculture is known as aquapreneur. According to Elfitasari *et al.*, (2021), a fishpreneur can be defined as a small-scale fish farmer with entrepreneurial behavior and who implements innovative actions as well as managerial strategies. Elfitasari *et al.,* (2021) described five characteistics of a fishpreneur (Fig. 2) including

- **Self-advertisement:** This is where the fishpreneur or aquapreneur advertise himself or herself in any media that will create traffic. Currently, a lot of entrepreneurs advertise their business through social media which have been proven to increase business performance (Olanrewaju *et al*., 2020).
- **Financial commitment:** This is one of the most important aspects of business because the success of any business depends on the ability to manage finances well will determine the success of the business (Elfitasari *et al*., 2021). According to Hosseini (2019), commitment is one of the most crucial entrepreneurial characters and having a good commitment to the financial aspect of the business is crucial.
- **Innovative actions:** Innovation is a good indicator of a good entrepreneur (Carland *et al*., 1984; Hosseini 2019). According to Elfitasari and Albert (2016), there are six innovative actions that are carried out by small scale fish farmers including extending the market for the products, expanding the product range, introducing other species for culture, producing own fish feed, and utilizing unwanted waste.
- **Visionary mindset:** The vision of a fishpreneur is also very crucial in the success of the business plan. A fishpreneur with a vision and mindset of expansion will do and learn anything to make his business to be successful. The enthusiasm about growing a mega business with creative plans and ideas defines an entrepreneur (Mukherjee, 2016).
- **New skills:** New skills are very important in any fish farming venture because every day, new innovations, techniques and methods that will enhance fish growth and boost productivity are coming out. Therefore, it is very important that a good fishpreneur should be willing to learn new skills that will help in boosting the successful business operation.

Fish production in Akwa Ibom State (Including fin and shell fishes)

Fish production in Akwa Ibom State which is obtained from two sources (capture fisheries and aquaculture) has contributed enormously to the gross domestic product of the State and that of the federation. Capture fisheries involves artisanal, industrial and recreational fish production whereas aquaculture involves the cultured of aquatic organisms including aquatic plants in a controlled environment.

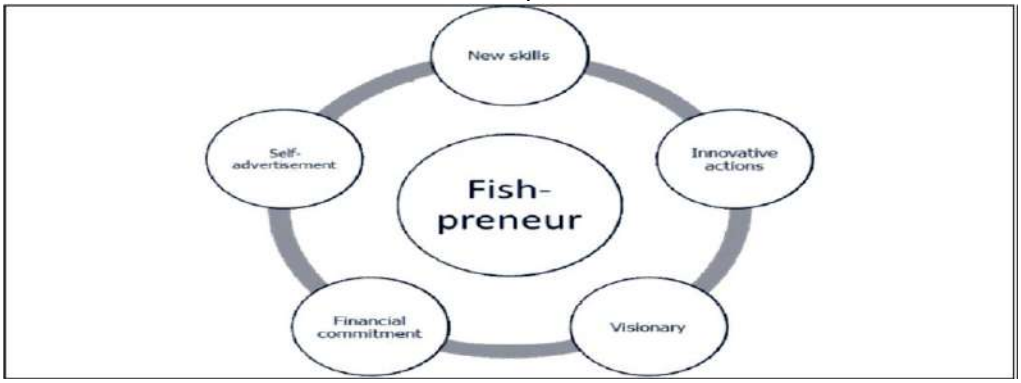

Fig. 2: Five characteristics of a fishpreneur (Source: Elfitasari *et al*., 2021)

Akwa Ibom State is rich with network of rivers, streams, seasonal flooded plains and tidal creeks, which are rich in diverse fisheries resources (Essien-Ibok and Isemin, 2020). Fish produced in Akwa Ibom State is obtained from inland waters such as Cross River, Qua Iboe River, coastal waters; rivers; marine waters, estuaries, creeks, floodplain, wetlands, mangrove swamps and fish ponds (Essen, 1990). According to Ekpo and Essien-Ibok (2013), Akwa Ibom State has a coastline of 129 km with a total effective shelf area of 8,005 km. Inland waters are crucial harbors for economically valuable fishes and some intrusive brackish and marine species migrates and use them as spawning and nursery grounds (Udo, 2012). Some of the inland waters in Akwa Ibom State are Ikpa River, Qua Iboe River, Iba Oku Stream, Ntak Inyang, Uta Ewa Creek etc. Table 1 shows the families and species of fish specimens caught in Qua Iboe River, Nigeri production obtained in different Local Government Areas may be attributed to various challenges faced by fish farmers which are highlighted in the later part of this paper. Both small-scale and large-scale farmers farm for profit. In Akwa Ibom State, fish species (Figs. 3 – 5) cultured by farmers include the African Catfish (*Clarias gariepinus*, *Heterobranchus longifilis*, *Heteroclarias*), Nile Tilapia (*Oreochromis niloticus*) and in very few farms, the Red Tilapia (*Oreochromis mossambicus* x *Oreochromis aureus*). These species dominate the cultivable fish species in Akwa Ibom State due to consumer's preference which is attributed to its excellent organoleptic properties nice meat quality, excellent taste after processing using different methods such as sun drying, oven-drying, frying, smoking, salting and barbecue (Awom and Eyo, 2021; Eyo and Eriegha, 2023). These fish species also exhibit fast growth rate, ease of breeding in captivity, tolerance to various environmental conditions, acceptability of artificial feed, relatively stable market prices, good food conversion ratio, and good marketability (Eyo *et al*., 2023). The type of rearing facilities that are mostly found in Akwa Ibom State (Figure 6 – 9) include earthen ponds, concrete tanks, tarpaulin tanks, metal tanks and glass aquaria. In these housing facilities, some farmers practice monoculture where only one fish species is cultured. Some farmers practice duoculture (culture of two similar species) and polyculture which involves the culture of two or more species in the same enclosure.

Table 1: Families and species of fish specimens caught in Qua Iboe River, Akwa Ibom State Nigeria

Family	Species
Polypteridae	*Erpetoichthys calabaricus*
Notopteridae	*Xenomystus nigri*
Mormyridae	*Brienomyrus brachyistius*
	Isichthys henryi
Characidae	*Brycinus longipinnis*
Cyprinidae	*Barbus callipterus*
Bagridae	*Anqspidoglanis fasciatus*
	A. akiri
	Chrysichthys aluuensis
Malapteruridae	*Malapterurus electricus*
Cyprinodontidae	*Epiplatys bifasciatus*
	E. sexfasciatus
Cichlidae	*Thysochromis ansorgii*
	Hemichromis fasciatus
	Chromidotilapia guntheri
	Tilapia mariae
	Pelvicachromis pulcher
Channidae	*Parachanna africana*
Anabantidae	*Ctenopoma nebulosum*
Nandidae	*Polycentropsis abbreviata*

Source: *Ekpo et al., (2014) cited in Essien-Ibok and Isemin (2020)*

Aquaculture production in Akwa Ibom State

Aquaculture production in Akwa Ibom State over the years has been growing steadily because of its profitable nature at all levels along the value chain. A total of 3,073,153 MT of fish was produced in the 31 Local Government Areas of the State (Table 2). Essien Udim producing the highest (1,012,300 ton), followed by Oron (295,200), followed by Ikot Abasi (255,811) whereas Eastern Obolo (1,230), Nsit Ibom (2,800), Nsit Atai (5,212) recorded very low production. The reasons for these variation in

Fig. 3: African Catfish (*Clarias gariepinus*) Sourc

Fig. 4: Nile Tilapia (*Oreochromis niloticus*)

Fig. 5: Red Tilapia (*Oreochromis mossambicus* x *Oreochromis aureus*)

Fig. 6: Earthen Pond

Fig. 8: Tarpaulin tanks

Fig. 7: Concrete tanks

Fig. 9: Glass aquarium

Table 2: Number of fish produced (Per Ton) in all the Local Government Areas of Akwa Ibom State in 2020

Local Govt. Areas	Number of fish produced (Per Ton)
Abak	95,718
Eastern Obolo	1,230
Eket	64,095
Esit Eket	72,230
Essien Udim	1,012,300
Etim Ekpo	81,830
Etinan	18,950
Ibeno	76,640
Ibesikpo	100,737
Ibiono	75,410
Ika	88,155
Ikono	47,828
Ikot Abasi	255,811
Ikot Ekpene	82,880
Ini	77,250
Itu	35,171
Mbo	28,094
Mkpat Enin	23,430
Nsit Atai	5,212
Nsit Ibom	2,800
Nsit Ubium	6,700
Obot Akara	93,590
Okobo	29,642
Onna	206,031
Oron	295,200
Oruk Anam	29,700
Udung Uko	21,960
Ukanafun	17,400
Uruan	33,949
Urue Offong	-
Uyo	69,210
Total	**3,073,153**

Source: Fisheries Directorate, Akwa Ibom State Ministry of Agriculture and Food Sufficiency (2020)

Fish Production as a source of livelihood and food security in Akwa Ibom State

From time immemorial, fish production has been one of the most important sources of livelihood for the inhabitants of the coastal States such as Akwa Ibom State. The fisher folk were solely dependent on the fisheries resources for their day to day affairs and fish production is considered as the custodian of livelihood security. Generally, fish production in food and nutrition security as fish is rich in protein, minerals, vitamins, omega 3 fatty acid, and other vital nutrients required for good health and growth (Eyo and Ekanem, 2011). It also helps in earning valuable foreign exchange, job and employment opportunities for millions of people. Different areas of livelihood sustenance through fish production are as follows:

- **Fingerlings production:** This is the hatchery production of healthy and fast-growing fingerlings for pond stocking or supply to fish farmers. Fingerlings are fish of 7 – 10 cm in length. Fingerlings production is one of the most profitable aspect of fish production as so much income can be generated if managed properly. Currently, 1 fingerling cost N30.00 and a matured gravid *Clarias gariepinus* (African Catfish) can produce over 100,000 eggs which can hatch into over 100,000 fingerlings in a single production.
- **Juvenile production**
  Juveniles are fishes ranging in size between 10 – 13 cm. Juveniles are more hardy and more resistant to diseases than fingerlings because they have a more developed immune system. Juveniles are more expensive than fingerlings and farmers selling juveniles will make more profit than those selling fingerlings.
- **Table size production**
  This is the production of fish that are ready for consumption. Depending on the species, the size of table size fish is usually from 200 g and above. Many fish farmers in Akwa Ibom State are practicing table size fish production. Often times, the price of table size fish per kilogram depends on the size of the table size fish. A bigger size of table size fish is more expensive per kilogram than a small size table size fish.

- **Broodstock production**
  This is the production of fish that are sexual maturity with the aim of using it for fingerlings production in hatcheries. High quality broodstock are very expensive and could be a good source of income generation to farmers.
- **Ornamental fish production**
  Ornamental fish production is one sector of the aquaculture industry that lacks attention and popularity in Akwa Ibom State. It involves the production and marketing of aquarium and all its components including, aquarium fishes, invertebrates, plants, rocks, filters, and aerators. Ornamental aquaculture or fish production is an exciting and rewarding business that is highly profitable. Business opportunities in aquarium production and supply is left unexplored in Akwa Ibom State and can provide a sustainable source of livelihood that will boost the economic growth of both the fishprenuer and the State.
- **Feed production**
  In fish production through aquaculture, feed is one of the most important input because it is responsible for over 70 % of the total cost of production (Eyo et al., 2014). Due to the expensive nature of feed, farmers are seriously constrained especially with the extremely high inflation level Nigeria is presently facing, which has not occurred in the last 30 – 40 years (Eriegha *et al*., 2022). Interestingly, cheaper but high feed can be produced using locally available ingredients such as maize, soybean, groundnut, breweries waste, fishmeal, palm kernel cake (PKC), cow blood and others. These ingredients are available in Akwa Ibom State presenting a viable business opportunity in the fish feed industry. Also, another business opportunity in feed production is to setup a feed mill for fish farmers to process their feed to their taste and are only charged for processing their feed. Supply of feed ingredients to farmers or feed mill owners is another lucrative business that is capable of sustaining livelihood in Akwa Ibom State.
- **Processed fish products and byproducts**
  Fish processing is the process which is associated with fish and fish products within the period in which fish are harvested or caught and the time in which the final product is delivered to the customer (Adeyeye, 2016). Fish processing is a traditional source of livelihood from time immemorial. Fish processing business presents various ways in which income can be generated to boost the economy and sustain livelihood and they include the following: Smoked fish, Barbecue fish, Pepper soup, Fish suya, Fisherman soup, Fried fish, Smoked fish soup, Fish oil, Fish glue, Fresh fish pepper soup, Fresh fish soup, Fish pie, Fishmeal

Challenges of entrepreneurship in fish production in Akwa Ibom State

Despite the increase in fish production, there are various challenges impeding the pace of fish production in Akwa Ibom State. Some of these challenges include:

- High investment costs especially in intensive fish farming.
- Unavailability of consultants for technical support
- Underutilization of certain State and Federal water bodies for aquaculture.
- Lack of steady market and distribution network for fish and fishery products,
- High cost and scarcity of high-quality fish feed
- Poor fish seed and broodfish supply
- Lack of developed potential of local ingredients for feeds.
- Lack of insurance for fish farming enterprises.
- Outbreak of fish diseases

- Poor water quality
- Lack of standard live fish transportation gadgets
- Lack of functional hatcheries and high-quality fish seeds
- Lack of basic amenities such as electricity, good access roads, water supply
- Lack of extension workers
- Lack of modern fish processing units
- Lack of molecular and fish disease diagnostic laboratories for genetic improvement, disease identification and management
- Use of obnoxious techniques such as application of fish fattening hormones
- Lack of facilities in research institutes to facilitate researches
- Lack of credit facilities and other incentives to farmers
- Lack of functional hatcheries for other aquaculture species
- Seasonal abundance of wild fish species such as *Chrysichthys nigrodigitatus* resulting reduce preference to cultured fishes and poor pricing by fish consumers
- Pollution of natural environment suitable for aquaculture projects
- Lack of baseline data for research, planning, development, and industrialization.
- Degradation of natural environment suitable for aquaculture projects
- Lack of quality control system for monitoring and evaluation.
- Inadequate training of extension workers on new and modern technique and practices to enhance fish production
- Loss of fishing inputs and poor recovery rate (Okoko, 2021)

Summary and Conclusion

Akwa Ibom State is rich in diverse fisheries resources including the fin fishes and the shellfishes and also has a suitable climate, topography and soil for aquaculture. This paper evaluated the entrepreneurship in fish production as a sustainable source of livelihood and economy booster in Akwa Ibom State and highlighted different areas that can generate income and employment. Different areas of livelihood sustenance through fish production highlighted in this paper include fingerlings production, juvenile production, table size production, broodstock production, ornamental fish production, feed production, setting up of feed mill, and supply of feed ingredients to farmers or feed mill owners. Fish processing business also presents various ways in which income can be generated to boost the economy and sustain livelihood such as smoked fish, barbecue fish, fish suya, fisherman soup, fried fish, smoked fish soup, fish oil, fish glue, fresh fish pepper soup, fresh fish soup, fish pie and fishmeal production. In conclusion, fish production is a reliable source of income generation, employment creation, food and nutrition security, and foreign exchange which can be harnessed to secure livelihood and boost the economy of Akwa Ibom State.

Recommendation

It is therefore recommended that indigenes and residents of Akwa Ibom State should utilize the entrepreneurial opportunities in the different value chain of fish production for a sustainable livelihood and economic growth of the State.

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The Entrepreneurship Of Agricultural Information Marketing In Nigeria: A Critical Review

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Abstract
The expanding agricultural value chain in Nigeria is bringing with it new actors and professionals into the agricultural information system towards increasing access to agricultural information and narrowing the disproportionate farmer-extension agent ratio in Nigeria. However, inadequate information handling and low credibility due to poor entrepreneurial skills in information marketing have been cited among significant setbacks posed by multiple actors' participation in the agricultural information system. The paper therefore provides a stylized review on the entrepreneurial implications of marketing agricultural information and technologies. From the findings of the paper, proficiency in agricultural information marketing essentially lies in adequate understanding of agricultural extension principles, as well as acquiring skills in script writing, electronic media production, instructional media production, content creation, video recording and production, digital photographic production, computer multimedia production, non-linear video and audio production, graphics designing and printing, agricultural journalism, computer programming/App development. The findings further revealed that while it is common to find those trained in the science of agricultural information marketing bereft of the aforementioned skillsets, the gatecrashers are usually more skillful but without technical depth in agricultural subject matter, thereby undermining the information validity. In the general analysis, agricultural information has become a commodity that can be exchanged for monetary benefits for both the sender and the user. Hence, it is recommended that those who engage in agricultural information marketing must be technically sound in theory and practice for efficient information delivery.

Keywords: Agricultural information marketing, communication, entrepreneurship, ICTs, professionalism, electronic media

CITATION:
Okoroma, E. O.,Udoh, E. J., Ekerete, B. U., Etuk, U. R. and Nwakwasi, R. N. (2023). The Entrepreneurship of Agricultural Information Marketing in Nigeria: A Critical Review. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 543-552

Introduction

The liberalization of information delivery and utilization championed through policy reforms and advanced use of Information Communication Technologies (ICTs) is increasingly changing the narrative around the concept of information. Today, the common assumption that, "information is power" has been transcribed to a more venturesome notation that sees "information as money", both for the sender and the receiver of the information. In a typical value chain where

information and ideas are required to flow across the components and actors for effective value chain activities, the information in many occasions are not easily accessible in usable format, making the information less believable and applicable in the context of the receiver (Okoroma *et al.,* 2021). Hence, the need for an intermediary who processes and delivers the information in transferable and usable formats.

Implicitly, meeting the information needs of agricultural stakeholders entails deploying multiple information channels that are capable of delivering technical information very fast and wide. That craving is increasingly finding satisfaction in the advancement and use of ICTs in facilitating and transmitting agricultural information to end users who are scattered across different locations (Food and Agricultural Organization (FAO), 2020). Thus, the trajectory of who is participating and how agricultural information is processed, stored, disseminated and accessed by the end users has remained evolutionary (Ifeanyi-obi and Ibiso, 2020). For instance, within the last two decades, information merchants like publishers, news bloggers, social media influencers, digital content creators, innovation experts, computer programmers/Application developers have massively moved into the agricultural information space. They are now using their print and electronic media spaces to disseminate agricultural information, such as, news of agricultural innovations, production techniques, processing methods, market information, hazard alert, credit/loan information, research result, Good Agricultural Practices (GAPs), soil conservation, information on postharvest handling for greater productivity (Ekerete *et al.,* 2021).

The influx of media professionals into agricultural information system is not unconnected with the rising number of internet users in Nigeria. As at the fourth quarter of 2021, Nigeria recorded 141,971,560 active internet users, representing about 71.0% of the nation's population (National Bureau of Statistics NBS, 2022).Apparently, the rationale is that since farmers who constitute about 40% of Nigeria's population make up a significant proportion of active internet users in Nigeria, targeting them with information merchandize will be a viable venture (Federal Ministry of Agriculture and Rural Development FMARD, 2016). Leveraging on the large number of active internet users and large readership of print media to market information typically describes entrepreneurship in agricultural information marketing (Patriotta and Siegel, 2019). It is in this regard that Agricultural information marketing is discussed as involving exchanging agricultural information for monetary benefits amidst the burden of risk, innovation and creativity. That is, the risk involved in running agriculture information marketing outfit; the innovation of deploying pertinent communication tools and gadgets for the task; and the creativity of gathering, processing and distributing information to the ultimate users.

However, as much as the entrepreneurial disposition of agricultural information marketers are promoting private extension service many experts are citing technical and ethical dilemmas to the multi stakeholder participation in the process. First, there are arguments that what most agricultural information marketers, especially those without formal background in agricultural extension disseminate is best described as news, since they often end at the level of stimulating interests without providing in-depth technical information and techniques that could lead to adoption of the information disseminated. There are fears that those who lack formal background in agriculture may not give recourse to any set of "dos" and "don'ts" in contravention to one of the metrics of successful information dissemination (Asiabaka, 2019). Implicitly, those trained to deliver agricultural information must acquire the requisite skills,

knowledge and favourable disposition necessary for the job.

The paper provides a stylized information about entrepreneurial implications of agricultural information marketing, by making a sense of the implicit meaning of entrepreneurship and agricultural information marketing, as well as highlighting the attributes, activities, requisite skills and challenges of agricultural information marketing.

Concept of Entrepreneurship

Entrepreneurship involves generating monetary benefits through responsive and innovative business venture (Gaddefors and Anderson, 2017). The process entails identifying existing needs, inadequacies, challenges, operational defects, information gaps, crude method, outdated information, incompatible technology, unproductive technique, and addressing them using creative approach, such as retooling existing technology, replacing old ideas with entirely new ones, creating location-specific contents, presenting existing facts in a new translation/version for the purpose of generating profit and sustaining the venture (Patriotta and Siegel, 2019). That is, taking conscious steps towards setting up an enterprise. Thus, those who devise new ways of delivering and utilizing information in exchange for payment can be regarded as information entrepreneurs, and the process involved as entrepreneurship. The penchant for monetary reward characterizes entrepreneurs as professionals, as well as explains why entrepreneurship and professionalism are interchangeably used in general context to connote individuals who get paid for creating new values and/or solutions through their products or services (Alo, 2004). By interpreting and presenting technical information in a way that makes it more understandable and appealing to the target receiver justification for payment is attained (Asiabaka, 2019).

However, while the definition of professionals as individuals who for the sake of monetary reward engage in activities others do for pleasure can be used to qualify entrepreneurs as professionals, it is important to state that professionals may not likewise be qualified as entrepreneurs. It takes more than providing services for monetary reward to become an entrepreneur. Alluding to this fact, the International Labour Organization (ILO), (2021) explained that unlike entrepreneurs whose characterizations are to innovate, create, disrupt and grow startups, professionals do not necessarily create startups. To earn monetary benefits, the functionalistic approach to entrepreneurship holds that an entrepreneur needs to be able to take the risk of starting up a new venture, in contrast to a professional whose business outlet lies in the skill sets with which to provide paid technical support services (Katila *et al*., 2012; Yetisen *et al.,* 2015). Many professionals are consultants without employees to pay or physical office to run and maintain, absolving them from most profit-making risks. The enormity of challenges faced by entrepreneurs explains why the Boost Africa Initiatives of the African Development Bank (AfDB) (2020) was designed to help young entrepreneurs in Africa boost their self-confidence, achievement drive, high locus of control, and the ability to shoulder the risk of owning and growing a startup. On the other hand, the contextual approach to entrepreneurship posits that success in agricultural information entrepreneurship does not only require demonstrating special sets of skills in creating, transmitting and utilizing agricultural information, but essentially involves following the professional ethics and conducts of agricultural information dissemination as provided in the principles of extension (Yetisen *et al.,* 2015; Asiabaka, 2019).

Agricultural Information Marketing

Agricultural information marketing entails leveraging electronic and non-electronic media channels in disseminating agricultural message to users of agricultural information and technologies for which payment is made by the receiver (Emerhirhi *et al*., 2020). Under the functionalistic approach to entrepreneurship, agricultural information marketers can be regarded as agriprenuers vis-à-vis the entrepreneurial traits they demonstrate in marketing agricultural information (Adel *et al*., 2020). By this understanding, it can be argued that the activities of those engaged in free agricultural information dissemination, such as public extension agents in Ministries of Agriculture and ADPs, as well as those with NGOs do not constitute information marketing in contrast to widely held views that describe the information dissemination of public extension agents as salesmanship. This position is reinforced by the fact that public extensionists are not employees of themselves, but that of the government, hence, can neither be described as entrepreneurs nor said to be engaged in entrepreneurship.

Agriprenuers engaged in electronic information marketing include online content creators, bloggers, photo journalists, digital marketers, media practitioners, cinematographers, app developers, research data marketers, market information. Those engaged in non-electronic information marketing include publishers of print media like books, magazine, newspaper, manuals, pictorials; public speakers, data analyst, and others who utilize individual and group methods of disseminating agricultural information. To sustain the agricultural production system, information needs to flow from and across all components of the production system through multiple channels and actors (Okoroma *et al.,*2015; Uzuegbunam, 2019). In doing this, credibility of the information and the source are critical elements that generate trust and respect which in turn creates believability on the part of the consumers (Nwosu, 2005). The outcome of a trusted source of agricultural information is that farmers and the receivers will see the message as being authentic, reliable and replicable in their own context. The activities of multi-players in the agricultural information system have not only raised the issue of credibility, but equally challenged the stereotype that portrays the agricultural information profession as the exclusive preserve of those with formal training. Nonetheless, to make this stereotype effective those with the statutory mandate of disseminating agricultural information such as the extensionists must develop capacity to promote the willingness and readiness of end users to pay for agricultural information.

Hence, it is important to note that getting end users to pay for agricultural information demands much more professional dexterity than just being a statutory information officer. Unlike the subsisting agricultural information system in Nigeria that is supply driven (mainly supplied freely by the government) to farmers, a demand-driven agricultural information marketing system relies on the value created by the professional skills of the players. Such as, performance abilities in market research, content writing, performance assessment, technical support services, digital marketing, website designing, computer programming/Application development, graphics design, advertising and sales representation, news blogging, publishing, electronic media production, social communication, innovation modeling. In other words, the path to attaining efficiency in agricultural information marketing lies in acquiring more professional skills that enable the information marketer participate in the creation, transmission and utilization of agricultural information

Entrepreneurial Attributes of Agricultural Information Marketers

Typically, professional agricultural information marketers are characterized by the following venturesome attributes:

a. They are venturesome and risk-takers in investing in communication tools and platforms that launch them wide and deep into the public space. Fintech investors, aggregators, innovation experts are capturing the markets using phone, web and other hand held electronic devices (AfDB, 2019; Ifeanyi-obi and Ibiso, 2020).

b. They leverage digital tools and platforms to achieve efficiency in capturing, processing, storing, sending and retrieving agricultural information. For instance, social media influencers who leverage their large network of followers; computer application developers who create App-driven information; graphic designers who exploit their captivating 3-D designs, digital markets who deploy multiple media to reach their target audience (Uzuegbunam, 2019).

c. They follow the trend in creating and selling their contents, as well as selecting their channels. At a time, Facebook was the most used social media for information marketing. Currently, twitter, instagram, blog pages, have also joined the league (AfDB, 2020).

d. They are creative writers and astute in producing news from their outlets, which gives them high readership and subscription (Okoroma *et al.*, 2015).

e. They are innovative always, trying out new channels and techniques of reaching more audience and covering the news space (FAO, 2020).

Entrepreneurship Activities in Agricultural Information Marketing

Advancement in the use of ICTs has continued to change the way agricultural information is disseminated. This change sometimes occurs spontaneously without the conscious efforts of the professionals. For instance, with the use of prerecorded video instructional material enable agricultural information professionals feature local farmers in the video to enable their counterparts see the message as authentic and replicable in their own context. Through this process those constrained by illiteracy are able to understand and effectively utilize the agricultural information (Okoroma *et al.*, 2015). The following areas have been found to offer huge entrepreneurial opportunities for agricultural information marketers in Nigeria, especially, in the wake of increasing deployment of electronic media:

i. **Agribusiness Market research:** Part of the primary needs of agro-product developers, manufacturers, merchants, investors, financiers, off-takers, aggregators, processors, and other members of the value chain is to get insight into what the market presents in terms of competitors, market share, consumer preference, commodity pricing, strength, opportunities, weaknesses and threats, especially for a new player or new product (FMARD, 2016). Such information is obtained by commissioning market researchers who deploy enumerators to field for data collection. The data collected are analyzed and results once generated can be published in different print media for onward distribution to the ultimate consumers.

ii. **Computer programming/Application development:** The increasing use of Web-based and mobile-based applications that allow for effective information exchange/interface between producers, facilitators and users of agricultural information, knowledge and technologies has increased the use and patronage of computer programmers/App developers. Mobile-based Applications are programmed to work with mobile phone settings. As such,

to use a mobile App, the same is first installed in a mobile phone. Agricultural communication is experiencing major changes as part of the impacts of this mobile phone utilization (Ifeanyi-Obi and Ibiso, 2020). Unlike the mobile App, a Web-based App is synchronized to the website making access to the App routed to a website. Notably, the dearth of computer programmers with technical background in agriculture has continued to limit the proficiency of programmers in developing agribusiness-specific apps. Technical background in agriculture is crucial in identifying critical areas of the value chain where needs can be transformed into opportunities using computer programming. Today, there are Apps that can enable information marketers keep adequate farm records for farmers, monitor and communicate market prices, access and communicate crowd funding, invest in other agribusiness ventures, access and purchase insurance policies, collect field data, access instant loan, meet off-takers/aggregators, obtain GIS information on the farm, etc. In fact, it is very likely that in the next decade most formal operations would be performed through the web or mobile Apps. At such time, computer programmers with formal knowledge of agriculture will become utility members of the agricultural sector.

iii. **Technical support/advisory services:** Information professionals involved in technical support service delivery deploy interactive channels like the Interactive Voice Response (IVR) which is an automated phone system facility that allows incoming callers access information through a voice response system of pre-recorded messages without having to speak to a receiver as well as utilize menu options through tone keypad selection or speech recognition to have their call routed to specific receiver (Aniemeka, 2017). Also, investors and farmers consult them for business planning, cost analysis, profitability, farm layout design, GAP, commodity prices, export market, bio-safety standards, input requirement, pests and disease control, etc.

iv. **Agricultural Information Publishing:** The use of the print media, such as magazine, news bulletin, newsletter, newspaper, handbook, stickers, innovation directory, calendar, instructional manual in advertising and disseminating information about agricultural innovations, commodity prices, production technologies, post-harvest handling, transportation and marketing, value chain integration, quality control has continued to increase with the changing trend (Okoroma *et al.,* 2015). These print materials may be purchased through market outlet point of sale; or couriered through online purchase and or periodic subscription.

v. **Electronic media production:** Electronic media refers to information/contents in softcopy format, such as video, audio, image, graphics, text. Agricultural information marketers package prerecorded voice notes, instructional videos, graphical designs, demonstration videos and pictures in CDs, DVDs, memory stick and other storage devices, or transmitted through online channels like social media platforms, website, blog sites, or broadcast media like TV and Radio (Okoroma *et al.*, 2021).

vi. **Agricultural information consultancy:** Consultancy involves the provision of independent advice and assistance to clients with management responsibilities (Imevbore, 2004). Consultants in agricultural information therefore assist clients gather agricultural information, analyze such information and provide advice based on the outcome of the analysis. Agricultural

information consultants usually have to be certified as meeting certain requirements relating to character, qualifications, experience, independence and competence in line with the provisions of the professional body issuing the certification. Consultancy services in agricultural information may focus on value chain development, production technology, agribusiness credit and loan facilitation, market information, product enhancement, rapid result appraisal, input use efficiency, entrepreneurship development, strategic marketing. People walk into agribusiness consultancy outfits to access advisory services for a fee.

vii. **Agricultural Content Blogging**: Blogs are news web pages dedicated to news reports, articles and features. Bloggers market agricultural information on request or to generate user traffic on their blog page. Typically, agricultural information marketed by bloggers include agricultural research information, agricultural market information , agribusiness plans, subscribed updates on produce aggregation and market prices.

viii. **Video/audio editors** – To effectively harness digital video/audio contents, such as short method and result demonstration video skits for information marketing. Non-linear video editors use video effects and sound transitions that enable them produce demonstration videos and audio recordings in local dialects for onward download and use (Okoroma *et al.,* 2015). To make such video and or audio user friendly, they are created and packaged in compatible file formats that allow general access and use.

Requisite Entrepreneurial Skills for Agricultural Information Marketing To succeed as an agricultural information marketer, especially, in an era that is highly integrated in digital creation, transmission and utilization of information the following skill areas according to Emerhirhi *et al.,* (2020) are critical:

a. Video recording and production
b. Digital photographic production
c. Computer multimedia production
d. Non-linear video and audio production
e. Graphics designing and printing
f. Script writing
g. Phone-based electronic media production
h. Web-based electronic media production
i. Instructional media production
j. Technical report writing
k. Market research
l. News reporting
m. Voicing/commentary
n. Impact assessment
o. App development/computer programming
p. Web designing/dentoprint
q. Software engineering
r. Agribusiness planning and management
s. Strategic marketing
t. Innovation modeling/pitching techniques

Challenges of Entrepreneurship in Agricultural Information Marketing

i. **Dearth of digital skills among agricultural communicators:** Unlike commodity market where the merchant needs to stock up goods, the selling point of a digital marketer is the skill or performance abilities. Unfortunately, the knowledge and use of digital contents and channels for agricultural information marketing is still at low level. Bakker and Addison (2019) described the situation as digital illiteracy which adds to the common problem of poor ICT infrastructure and power supply, including high costs of services which have limited electronic information marketing. This problem is compounded by the gap between what the industry needs and the training contents offered to both a pre-service and in-service levels. In many cases, training contents are not derived from needs assessment. The latter helps to identify the training needs and conditions for the training.

ii. **Poor access to agricultural information:** Weak communication and linkages among farmers and agricultural information generating sources, such as research institutes, extension agencies, interventionist agencies, training institutions constitute a challenge to information marketing (Akinnagbe *et al.,* 2017). Access to information implies that the target audience has the capability and capacity to get available agricultural information as well as being able to utilize the available. The weak linkage makes it difficult for farmers to know and go for agricultural information of their choice. Unfortunately, in many instances, information may be available without corresponding ability to use the information available. For this reason, what research has promised to be feasible and achievable in one hand become different from what obtains in the field (Nwachukwu, 2003).

iii. **Lack of adequate training:** The ever-changing trend in agribusiness requires that training contents given to agricultural information officers both at pre-service and in-service stages are periodically reviewed to reflect the new realities. Unfortunately, curricula contents delivered across training institutions in Nigeria on agricultural information marketing are either deficient of key practical guides or offered vaguely. Training for extension agents and information office scan help them learn the basics of information marketing and usage. This could help equip them to access different online training courses or upgrade their knowledge. Training induces motivation, increased knowledge and value of human resources among extension agents (Man *et al.*, 2016).

iv. **Lack of startup funding:** The reality is that agricultural information marketing is more likely to thrive under private proprietorship than under any public framework. Hence, the need for external funding support scheme from which startups in agricultural information marketing can be funded. In addition to the seed money, startup funding involves mentorship, pitching/innovation management techniques. With very few manpower development opportunities available to agricultural information marketers not much has been achieved in the area of funding startups thereby stagnating the number of people engaged in agricultural information marketing, especially, through digital channels (AfDB, 2020).

v. Unavailability of internet facilities,

vi. lack of basic ICT facilities

Conclusion and Recommendations

Agricultural information has become a commodity that can be exchanged for the monetary benefits of both the sender and those who utilize the information. It is predicated on existing information needs of the target audience to enable them rise above their needs. The business of disseminating agricultural information on the basis of payment entails agripreneurship and those who engage in it are regarded as agripreneurs or information marketers. They are inter alia known for their venturesome and risk-taking disposition; innovativeness; digital capability; creativity in writing; trendy compliance. agribusiness market research, computer programming/application development, technical support/advisory services, agricultural information publishing, electronic media production, agricultural information consultancy, agricultural content blogging, video/audio editors are areas of entrepreneurial opportunities for agricultural information marketers. To succeed in the aforementioned the agripreneur among others needs to acquire skills in video recording and production, digital photographic production, computer multimedia production, Non-linear video and audio production, Graphics designing

and printing, Script writing, Phone-based electronic media production, Web-based electronic media production, Instructional media production, App development/computer programming. Dearth of digital skills among agricultural communicators, poor access to agricultural information, Lack of adequate training, lack of startup funding, unavailability of internet facilities, lack of basic ICT facilities are challenges of entrepreneurship in agricultural information marketing. Hence, it is recommended that:

- **Reviewing Digital Curriculum in Agricultural Communication:** Agricultural communication curriculum should be rejigged to equip students and trainees of agricultural communication with the requite skill set, such as mentioned earlier in order to make the graduates and discipline relevant and productive in an era that thrives on digital and knowledge economy. It is sad to observe that under the subsisting curriculum, pertinent digital skills, such as nonlinear editing, video production, audio production, photography, graphics, broadcasting, journalism, studio management, electronic content writing, coding/programming, Visualization, Animation, Robotics, data simulation, etc, are either not taught or vaguely taught without practical components, exacerbating digital performance gap amongst graduates and trainees of agricultural communication. In fact, what presents in most cases is that digital agricultural communication is subsumed into ICTs and taught without recourse to the trajectory of digital content creation, transmission and utilization. It is important to note that while ICTs focus on the tools, digital communication encompasses both the process and the tools. Hence, a rejigged curriculum will go beyond the usual ICT discourse and deepen knowledge and skills in digital communication through simulations, training and applications of digital process and tools. The new paradigm must involve a backward integration that moves agricultural communicators from consumption of digital contents back to creation and transmission of digital contents. By so doing, we will among other things be able to influence significantly the trajectory and quality of agricultural innovations and technologies disseminated through the digital space. Meanwhile, without training those who will teach the new curriculum, the purpose will not be achieved. Hence, as part of the review efforts, there is need to encourage agricultural communication lecturers, technologists and students through grants, scholarship, employment to undertake short courses, certifications, trainings or PGD/PhD in digital production. This will not only increase technical capacity and multidisciplinary skill integration in agricultural communication, but essentially promote entrepreneurial development in agricultural communication.
- **Increasing access to agricultural information:** In the wake of the ineffective and limited supply-driven agricultural information dissemination system funded and provided free by the government, agricultural information marketing is intended to increase access to agricultural information through the participation of private information merchants. This is part of strategic efforts in promoting private agricultural extension practice in which graduates and trainees of agricultural extension will become independent sources of credible information in agriculture. Thus, it is easy to optimize multiple communication channels.
- **Increasing training in information marketing:** Once the aforementioned steps are taken, it will have the right manpower to optimize the use of audiovisual laboratories across our institutions, as well as transfer same skills and abilities to our undergraduates to make them competitive in digital

communication. Our graduates will leave with skills and abilities that not only keep them self-employed, but also change the frontiers of extension education and profession in Nigeria to a more Private oriented and Tech-based profession.

- Institutions of higher learning should go into collaborative funding with private organizations and other agencies of the government towards identifying and funding groundbreaking Startups in agricultural information marketing. This will inspire others to venture.
- Institutions should partner with internet service providers in providing internet cloud and connectivity within the institution to enable easy access to the internet.
- As a perquisite for NUC accreditation, institutions offering agricultural extension have audio-visual laboratories which provides environment where tools used for agricultural communication are domiciled. Unfortunately, due to dearth of technical manpower most audio-visual laboratories are rather used as stores for ICT tools than for teaching and learning; used as where practical training, simulation and demonstrations are carried out for training purposes. Hence, the need to optimize the use of audio-visual laboratories for manpower development in agricultural communication.
- Animations of different IT packages can be developed in different languages and made readily available to stakeholders on how to operate/use ICT gadgets to enhance business.

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Entrepreneurship Skills Acquisition And Self Employment Intentions Of Prospective Secondary School Leavers In Akwa Ibom North East Senatorial District, Nigeria

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Abstract: *This study aimed at determining the relationship between entrepreneurship skills acquisition and self employment intentions of prospective secondary school leavers in Akwa Ibom North East Senatorial District, Nigeria. Two research questions were raised, and two hypotheses formulated and tested at .05 level of significance. A correlational research design was adopted while the population of the study comprised 20,272 SS2 students in the 89 public secondary schools in the study area. A sample size of 392 Senior Secondary Two (SS2) students was selected from the total population using Taro Yamane sample formulae. Systematic random sampling technique was used to select four (4) Local Government Areas (LGAs) for the study out of nine. For proper selection of sampled schools and students, balloting method of random sampling was used to select 14 schools out of 89 as well as 28 students per sampled school for instrument administration, giving a total of 392 sampled respondents. The researchers' structured questionnaire instrument titled: "Entrepreneurship Skills Acquisition and Self-employment Intentions of Students Questionnaire (ESASISQ)" were used for data collection. Data generated from the administered instrument were analyzed using Pearson Product Moment Correlation (PPMC) statistics. "The research findings revealed a very high positive and significance relationship between creativity skills, ICT skills and self employment intentions of prospective secondary school leavers in the study area. Conclusion was drawn from the findings while the researchers recommend among other things that, through entrepreneurial studies in secondary schools, students should be taught the basic entrepreneurship skills and how to develop a viable business plan while in school so that they can cultivate creative abilities in establishing jobs for themselves after leaving the school.*

Keywords: Entrepreneurship skill acquisition, self-employment intentions, creativity skills, ICT skills

CITATION:

Udoh, G. J., Onofiok, B. W. and James, I. O. (2023). Entrepreneurship Skills Acquisition and Self Employment Intentions of Prospective Secondary School Leavers in Akwa Ibom North East Senatorial District, Nigeria. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 531-541

Introduction

Entrepreneurship skills are broad range of skills instrumental in spurring social change and improving the way people live and work. Entrepreneurship play a key role in any economy, using the skills and initiative necessary to anticipate needs and bringing new marketable ideas. Entrepreneurs promote economic development, foster innovation and creation of jobs. The important key to success of entrepreneurship skills acquisition in Nigeria is education and training. As noted by Njoroge and Gathungu (2013), the school remains the place where most (holistic) profound impact can be brought about in the development of the youth. The inability of graduates to contribute meaningfully to economic development through self-employment informed the introduction of

entrepreneurship education in secondary schools. Entrepreneurship education is a set of formalized teachings that trains and educates young ones to promote entrepreneurship awareness and business creation (Dambo and Enyekit, 2017). It is education that supports entrepreneurial activities, behaviours, and outlook. Entrepreneurship education is a means of inculcating self-employment culture and entrepreneurship skills in students at secondary schools. In Nigeria, science and technology are recognized as powerful instruments for national development. It is in realization of this that Abanyam (2014) noted that Nigeria had to diversify her secondary school curriculum to integrate academic knowledge with technical and vocational skills to equip the students with relevant knowledge and skills for self employment. Nigeria widened the scope of secondary school curricular to integrate technical and vocational studies for practical acquisition of entrepreneurship skills and competencies required for the individual to be self-employed and contribute to the development of the society (Aja-Okorie and Adali, 2013).

Sequel to the introduction of entrepreneurship education in the secondary school curriculum, it becomes imperative to incorporate vocational subjects as one of the specific goals of Upper Basic (JS1-3) and Post Basic (SS1-3) secondary education, aimed at providing technical knowledge and vocational skills necessary for agriculture, industrial and economic development (Uzoamaka, Onyemaechi, Ngozi and Ezenwaji, 2016). The curricular of upper basic and post basic education contain trade/entrepreneurship elective subjects such as business studies, home economics, wood work, commerce, food and nutrition, building, construction, local crafts, computer education, agricultural science and so on (Ofoha,2011). Hence, secondary school leavers are expected to acquire entrepreneurship skills through these subjects, such as communication skills, marketing skills, creativity skills, financial management, innovation, decision-making and human relationship skills to become active entrepreneurs who are more creative and self-reliance after graduation.

Creativity skill is one of the entrepreneurship skills which may likely help young one to be self-employed after graduation from secondary school and even in the University. Creativity, according to Omeke (2011) is a mental process undertaken by an individual or group to solve specific problems resulting in the production of statistically infrequent solutions which are useful to the society and the creator. Creativity obviously involves some form of display of ability to do something and most often in a new way of solving problems. It involves developing problem solving skills, evolving new technologies and ways of solving problems. Abdulkarim (2012) asserted that possession of creative skill gives rise to self-employment. Creativity and innovation are inseparable from entrepreneurship, which in turn, manifested in the act of starting up and running enterprise. When creativity is lacking, it is obvious that a coherent framework for the implementation of a strong entrepreneurship culture will equally be missing; thus, resulting in unemployment, lack of innovation and increase in social vices.

Information and Communication Technology (ICT) skill is also relevant skills which may likely help young ones to be self employed. For effective management of business, ICT skills are one of the basic competences expected of entrepreneur. Information and Communication Technology (ICT) skill is defined as ability to use digital technologies, communication tools, and/or networks to solve information problems in order to function well in an information society. Gnudi and Lorenzi, (2012) noted that for someone to become a good entrepreneur, he or she must be able to independently operate

personal computer systems; use software for preparing and presenting work; use internet and its various features; access and use information from World Wide Web (WWW) and many other ICT packages. The authors added that it is disheartening that some graduate from the university lack the skills of ICT in facilitating the marketing of goods and services and as such, limits the penetration and awareness of their products in the market.

Secondary school education is expected to prepare citizens with basic entrepreneurship skills for self-reliance, creative empowerment, and nation building. The growing level of unemployment among secondary school leavers has enormous social and economic consequences which poses serious threat to the cohesion and stability of the Nigerian society. It is against this backdrop that this researcher sought to investigate entrepreneurship skills acquisition and self employment intentions of prospective secondary school leavers in Akwa Ibom North East Senatorial District, Nigeria.

Theoretical and Conceptual Review

Theory of Skill Acquisition by Dreyfus Hubert and Stuart Dreyfus (1986)

Dreyfus Hubert and Dreyfus Stuart in 1986 propounded the theory of skill acquisition, which states that formal system of deduction is a gradual process that involves being embodied in different ways and developing skills that would make it possible for people to deal with the world. The theorists stated that a student goes through at least five stages of different knowledge of a specific tasks and ways of decision-making as he improves his skill. These five stages are novice, advanced beginner, competence, proficiency, and expertise.

This assertion holds true in entrepreneurship education in secondary schools, where both theoretical and practical aspects of entrepreneurship are taught to the students, who before now had little or no knowledge about such courses. The novice stage is a stage where students have some general ideas and is in the process of learning the rules, with no responsibility beyond following the rules exactly. Hence, at this level, students are exposed to basic principles of skills acquisition through entrepreneurship education and other related introductory knowledge, which will prepare him higher level skills.

At the advanced beginner stage, the individual is faced with limited situational perception. All aspect of work is treated to equal importance. The competence stage is when an individual develops organizing principles to quickly access the rules that are relevant to the specific tasks at hand. The proficiency stage is shown by individual who develops intuition to guide their decisions and devise their own rules to formulate plans. Their progression is from rigid adherence to rules to an intuitive mode of reasoning based on tacit knowledge. The students while intuitively understanding his task, still thinks analytically about his actions. At this level, he or she think creatively what he can do to become self employed after graduation, analyzing the possible ways of raising fund, locating his business, and other business strategies will come to mind at this stage.

Finally, the last stage is called expertise where an individual has mature understanding of the task. At this level, a student can create jobs which will in turn make a student self-employed. This theory is related to this work in that it explainedexplicitly that student self-employment intentions are based on their learning of entrepreneurship skills which are developed gradually.

Entrepreneurship Skills Acquisition

Skill is the ability to show expertise in carrying out certain tasks. Igwe (2010) posited that skill is the art of possessing the ability, power, authority, or competency to do the task required of an individual n the job. Two fundamental issues are used when a skill is to be acquired.

According to Okoro and Ursula (2012), the first is the conditions which promote acquisition and the second is the change that will occur when the skill is acquired. The authors added that when somebody acquires skills in any occupation, such a person can establish his own business and even employ others. The person becomes self-reliant, self-sufficient, and self-employed.

Entrepreneurship is the willingness and ability of an individual to seek out investment opportunities, establish and run an enterprise successfully. Entrepreneurship is thus, the process of learning the skills needed to assume the risk of establishing a business. Akpotowoh and Amahi (2010) opined that the skills acquired in any of the functional areas of business -related programme promotes training in entrepreneurship as well as equip graduates with requisite potentials to establish and run small businesses on their own. In nutshell, entrepreneurship skill acquisition is a training programmes that is geared towards equipped learners with creative ideas that would enhance self-employment and job creation.

Self-Employment Intentions

Self-employment refers to the situation where an individual creates and takes control of a business decisions. Abdulkarim (2012) defined self-employment as working for oneself. The implication is that the person is his own boss, and he takes every decision involving the business. Self-employment is an important driver of entrepreneurship and job creation and thus contributes to the development and growth in job creation. Self-employment intention is defined as the intention to start the new business for self-development and reliance. According to Dugassa (2012) self-employment intention is a conscious state of mind that precedes action and direct attention towards entrepreneurial behaviours such as starting a new business becoming an entrepreneur. Al-Qadasi, Zhang and Al-Jubari (2021) defined self-employment intention as an individual willingness to start a new venture after graduation. Entrepreneurship education improves motivation towards being entrepreneurial by motivating students' personal attraction towards entrepreneurship and perceived behavioural control.

Creativity Skills and Self-Employment Intentions of Students

The high rate of unemployment in the Nigeria requires creative and critical thinking ability to meet the challenges of unemployment. Creativity is very important because it is inevitable for success in job creation. Oziko (2009) stated that creativity is a mental process that involves the application of divergent thinking, critical thinking, and other problem-solving skills in order to provide solution to problems. Creativity, according to Abanyam (2014) is a mental process undertaken by an individual or group to solve specific problems resulting in the production of statistically infrequent solutions which are useful to the society and the creator. Creativity is the ability to bring into existence new ideas, be it an artistic object or form, a solution to a problem, or a method, or a device.

According to Abdulkarim (2012), the possession of creative skill gives rise to self-employment. The author added that creativity obviously involves some form of display of ability to do something and most often in a new way. It involves developing problem solving skills, solving new technologies and ways of solving problem. The whole idea about entrepreneurship is creativity which will generate employment opportunities to others. Creativity is the most effective method for bridging the gap between science and the marketplace, creating new enterprises, and bringing new products and services to the market. These entrepreneurial activities

significantly affect the economy of an area by building the economic base and providing jobs.

To succeed in today's competitive market as an entrepreneur; one needs to broad array of creative skills. Terry (2015) argued that business owners need to possess basic skills necessary to start, develop, finance and market own business. According to Akpotowoh and Amahi (2010), the skills acquired in any of the area of business-related programme promotes training in creativity as well as equip graduates with requisite skills to establish and run small businesses of their own. In one of the studies conducted by Mason, Williams, and Cranmer (2016), the authors revealed a significant influence of creativity skills on self-employment initiative of students. This finding is also in line with the finding of the study conducted by Abdulkarim (2012), that creativity and innovation are vital in starting up and running enterprises. The author added that the whole idea about entrepreneurship is about creativity which will generate employment opportunities to others.

ICT Skills and Self-Employment Intentions of Students

ICT skill is defined as the ability to use digital technologies, communication tools, and/or networks to solve information problems in order to function in an information society (Tesch, Murphy and Crable, 2009). This includes the ability to use technology as a tool to research, organize, evaluate, and communicate information and the possession of a fundamental understanding of the ethical/legal issues surrounding the access and use of information. With the possession of these skills, the business education graduate would have been adequately prepared for self employment. The creative use of Information and Communications Technology (ICT) in education has the capacity to increase the quality of people's lives by enhancing teaching and learning.

Today's organizations demand that workers have a basic level of computer literacy due to their dependency on computers to operate better, faster, and cheaper. Keengwe (2010) pontificated that most students lack computer skill in various computer applications that are necessary to support and enhance their learning experience. Johnson, Bartholomew, and Miller (2011) aver that preparing students for employment and beyond requires that the current and emerging needs of industry be assessed in an effort to ensure that graduates are equipped with toolkits to be productive.

The six ICT skills are expected of secondary school students for self-employment are ability to independently operate personal computer system; use software for preparing and presenting work; use internet and its various features; access and use information from WWW; use an e learning platform and, perform data analysis with a computer package (Gnudi and Lorenzi, 2012). In a study conducted by Eyitayo (2012), the author found that students are most likely to make self-employment decision based on the possession of ICT skills. This finding also agrees with the finding of the study conducted by McDonald (2014), which revealed that students who are computer literate are most likely to demonstrate eagerness for self employment activities. The author added that if secondary school students have to become successful entrepreneurs that are self dependent, they need to possess knowledge of ICT skills.

Statement of the Problem

Entrepreneurship education programmes equips individual with necessary skills for self employment. One of the goals of entrepreneurship education is the acquisition of both physical and intellectual skills which will enable individuals to be self-reliant and useful

members of the society. Despite the importance of entrepreneurship education for self employment, it is very common to find most secondary school leavers roam the street in search of jobs, which are either few in supply or not available. Even the few ones who try to establish businesses could not succeed to keep the business booming probably because of poor location of businesses, lack of creative thinking, poor communication and interpersonal relationship skills, ICT competences among others.

Consequently, the poor maximization of entrepreneurial skills for self-employment has made most secondary school leavers to not attain economic self-reliance, which has resulted in increased rate of unemployment. Most youths in the study area engaged in drugs, sexual abuse, social instability, conflict, militancy, hooliganism, greater poverty, thuggery, arm robbery, restiveness, ethnic-political clashes, and other social vices, all of wish occurs due to unemployment. Therefore, the skills possesed by secondary school leavers for self employment is doubtful considering the rate of unemployment and crimes; hence the resolve to conduct an empirical study aimed at determining the relationship between entrepreneurship skills acquisition and self employment intentions of prospective secondary school leavers in Akwa Ibom North East Senatorial District, Nigeria.

Research Questions

The following research questions were raised for the study:

1. What is the relationship between creativity skills and self employment intentions of prospective secondary school leavers in Akwa Ibom North East Senatorial District?
2. What is the relationship between ICT skills and self employment intentions of prospective secondary school leavers in Akwa Ibom North East Senatorial District?

Research Hypotheses

The following research hypotheses were formulated and tested at .05 level of significance

1. There is no significant relationship between creativity skills and self employment intentions of prospective secondary school leavers in Akwa Ibom North East Senatorial District.
2. There is no significant relationship between ICT skills and self employment intentions of prospective secondary school leavers in Akwa Ibom North East Senatorial District.

Research Method

Design of the Study

The correlational research design was adopted for the study. This design is used in finding out the magnitude and direction of relationship that exists between the dependent and independent variables (Nassaji, 2015). Therefore, this design was considered suitable for this study because it enabled the researcher to measure the interrelationship between entrepreneurship skills acquisition and self employment intentions of prospective secondary school leavers in Akwa Ibom North East Senatorial District.

Population of the Study

The population of the study comprised all 20,272 Senior Secondary Two (SS2) students in the 89 public secondary schools that make up Akwa Ibom North-East Senatorial Districts namely: Etinan, Ibesikpo Asutan, Ibiono Ibom, Itu, Nsit Atai, Nsit Ibom, Nsit Ubium, Uruan and Uyo. (Department of Planning and Research Statistics: State Secondary Education Board, Uyo 2022).

Sample and Sampling Technique

A sample size of 392 Senior Secondary Two (SS2) students was selected from the total population through the use of Taro Yamane sample formulae. Systematic random sampling technique was used to select four (4) Local Government Areas (LGAs) for the study out of nine. This was done by arranging the numerical from 1 to 9, thereafter; every even-numbered

LGAs were selected for the study. For proper selection of sampled schools, balloting method of random sampling was used to select 14 sampled schools out of 89. Thereafter, 28 SS2 students were selected from each of the 14 sampled schools for instrument administration using the same balloting method of random sampling, giving a total of 392 sampled respondents.

Instrumentation

The researchers' structured questionnaire instrument titled: "Entrepreneurship Skills Acquisition and Self-employment Intentions of Students Questionnaire (ESASISQ)" were used for data collection. The ESASISQ questionnaire had two sections. Section A contained ten items, that is five items each on creative and ICT skills while section B contained 8 items measuring self-employment intentions of students. ESASISQ was scored using a four point rating scale of: Strongly Agree (SA) = 4, Agree (A) = 3, Disagree = 2, Strongly Disagree (SD) = 1. The respondents were requested to give their own opinions or views to the instrument using the symbol (r).

Reliability of the Instrument

To establish the reliability of the instrument, Cronbach Alpha reliability technique was used. Hence, the instrument was administered on 30 SS2 students in a selected school not included in the sample population. Data were subjected to correlation and Cronbach Alpha statistics was applied for test of internal consistency of the instrument. This yielded the overall reliability index of .81 for the independent variables and .88 for the dependent variables. This index according to Udoh and Joseph (2005) is a very high reliability index since reliability co-efficient is above .50. Therefore, the instrument was deemed reliable for use in the study.

Method of Data Analysis

Data generated were analyzed using Pearson Product Moment Correlation (PPMC) to answer the research questions. The same statistical tool (PPMC) was used for testing of the null hypotheses by comparing the r-value with the critical r-value, so as to determine the significance of the relationship between variables all at .05 level of significance. The research questions were answered using the decision rule presented by Nunnally (2011) as follows:

Coefficient (r) - Relationship

1.00

± .71 to ± .99 - Very high positive relationship

± .50 to ± .70 - High positive relationship

± .35 to ± .49 - Average or moderate positive relationship

± .33 to ± .34 - Weak positive relationship

± .10 to ± .22 - Very weak positive relationship

For the null hypotheses, the standard for decision was to reject the research hypotheses when the calculated r-value is greater than or equals to the critical value, and retained when the calculated value is less than the critical value.

Results and Discussion

Research Question 1

What is the relationship between creativity skills and self employment intentions of prospective secondary school leavers in Akwa Ibom North East Senatorial District?

Result in Table 1 shows a correlation value of 0.86. From the decision rule, it is noticed that a very high positive relationship exists between creativity skills and self-employment intentions of prospective secondary school leavers in Akwa Ibom North East Senatorial District.

Table 1: Correlation analysis of responses between creativity skills and self-employment intentions of prospective secondary school leavers

Variables	n	∑x ∑y	∑x² value ∑y²	∑xy	r-value	Remark
Creativity Skills (x)	378	5416	76984			
Self-emplomen Intentions of Students (y)				782371	0.86	Very High Positive Relationship
	378	5494	74718			

Researcher's field work (2022)

The implication of this result is that students are most likely to develop positive intentions for self-employment if they possess creativity skills such as ability to identify business opportunities, generate ideas suitable to the opportunities identified, set appropriate businesses goals and vice versa.

Research Question 2

What is the relationship between ICT skills and self-employment intentions of prospective secondary school leavers in Akwa Ibom North East Senatorial District?

Table 2: Correlation analysis of responses between ICT skills and self-employment intentions of prospective secondary school leavers

Variables	n	∑x ∑y	∑x² value ∑y²	∑xy	r-value	Remark
ICT Skills (x)	378	5426	76884			
Self-emplomen Intentions of Students (y)			735533	0.74		Very High Positive Relationship
			74718			
	378	5494				

Researcher's field work (2022)

Result in Table 2 shows a correlation value of 0.74. From the decision rule, it is noticed that a very high positive relationship exists between ICT skills and self-employment intentions of prospective secondary school leavers in Akwa Ibom North East Senatorial District. The implication of this result is that students are most likely to cultivate positive for intentions for self-employment if they possess skills to interact professionally with customers using ICT programs and soft wares and vice versa.

Hypotheses Testing

Hypothesis 1

There is no significant relationship between creativity skills and self employment intentions of prospective secondary school leavers in Akwa Ibom North East Senatorial District.

Table 3 shows that the calculated r-value of 0.86 is greater than the critical value of 0.194 at the degree of freedom of 376 and at .05 significant levels. Hence, the null hypothesis is therefore rejected, while the alternate hypothesis is retained. This implies that there is a significant relationship between creativity skills and self-employment intentions of prospective secondary school leavers in Akwa Ibom North East Senatorial District

Table 3: Pearson Product Moment Correlation analysis between creativity skills and self-employment intentions of prospective secondary school leavers

Variables	N	∑x ∑y	∑x² ∑y²	∑xy	r-value	r-crit	Decision
Creativity Skills (x)	378	5416	76984				
						0.194	Rejected H_o
Self-emploment Intentions of Students (y)				782371	0.86*		
	378	5494	74718				

** Significant; P<.05; df = 376; critical r = 0.194 .*

Table 4: Pearson Product Moment Correlation analysis between ICT skills and self employment intentions of prospective secondary school leavers

Variables	N	∑x ∑y	∑x2 ∑y2	∑xy	r-value	r-crit	Decision
ICT Skills (x)	378	5426	76884				
				735533	0.74*		
Self-emploment			74718			0.194	Rejected
Intentions of Students (y)	378	5494				H_o	

*** Significant; P<.05; df = 376; critical r = 0.194**

Hypothesis 2

There is no significant relationship between ICT skills and self employment intentions of prospective secondary school leavers in Akwa Ibom North East Senatorial District

Table 4 shows that the calculated r-value of 0.74 is greater than the critical value of 0.194 at the degree of freedom of 376 and at .05 significant levels. Hence, the null hypothesis is therefore rejected, while the alternate hypothesis is retained. This implies that there is a significant relationship between ICT skills and self employment intentions of prospective secondary school leavers in Akwa Ibom North East Senatorial District.

Discussion

The researcher made a combined discussion of findings from the research questions and hypotheses of the study.

Results from research question one and hypothesis one revealed a very high positive and significant relationship between creativity skills and self employment intentions of prospective secondary school leavers in Akwa Ibom North East Senatorial District. This finding agrees with finding of the study conducted by Abdulkarim (2012), who found that creativity and innovation are vital in starting up and running enterprises. The author added that the whole idea about entrepreneurship is about creativity which will generate employment opportunities to others. This finding is also in tandem with that of Mason, Williams, and Cranmer (2016), which revealed a significant influence of creativity skills on self-employment initiative of students. Hence, it is therefore observed that creativity skills are essential for business start-ups intention among students.

Results from research question two and hypothesis two revealed a very high positive and significant relationship between ICT skills and attitude towards self-employment among year three students in the University of Uyo. This

finding agrees with finding of the study conducted by Eyitayo (2012), that students are most likely to make self-employment decision based on the possession of ICT skills. This finding also agrees with that of McDonald (2014), who found that students who are computer literate are most likely to demonstrate eagerness for self employment activities. The author added that if students are to become successful entrepreneurs, they need to possess knowledge of ICT skills. This means that students who intend to become self employed must acquire adequate computer knowledge (concepts) and computer skills (applications). Such skills involved the ability to used ICT programmes such as Word Processing, Database, Spreadsheet, Desktop Publishing, Graphics and Design, Presentation, and Web Page editors programs.

Conclusion

Based on the finding of the study, it is therefore concluded that secondary school students need to possess creativity and use of information and communication technology skills which are necessary for self-employment and sustainable development.

Implications for Counselling

The need for entrepreneurship education has become more imperative particularly in this 21st century where existing vacancies in public and private institution are limited to accommodate the teaming unemployed youths. Thus, the believe that people survival lies in government service have resulted in increased unemployment, idleness, and involvement in social vices due to the inability of our youths to create jobs for themselves.

This study has implications for school counsellors to regularly informed parents through PTA meetings on the importance of being a positive role model in sparking creativity and entrepreneurship dreams in children. Also, the study findings have made it imperative for school counsellors to encourage parents' utilization of their acquired knowledge in business venture to help children develop their entrepreneurial ability and competences.

The findings of the study have implications for school counsellors in advising secondary school students to cultivate positive attitude towards entrepreneurship skills acquisition activities in school, so that they can develop the mindset of becoming entrepreneurs as well learning the skills relevant for successful entrepreneurship development. The study findings also have implications to the government, in ensuring that qualified guidance and counselling officers are employed in all public schools so that young one can received adequate orientation and enlightenment on the benefits of becoming self-employed and available entrepreneurship options.

Recommendations

Based on the findings, the following recommendations were made:

1. Through entrepreneurial studies in secondary schools, students should be taught the basic entrepreneurship skills and how to develop a viable business plan while in school so that they can cultivate creative abilities in establishing jobs for themselves after leaving the school.
2. Students should be taught modern information and communication technology tools and packages in entrepreneurship classes. Also, trained personnel should be employed to handle the ICT units for effective impartation of knowledge and skills on the students.

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A Review Of Pollution And Its Effects On Community Health In Nigeria

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Abstract: *Pollutions and its effects on the community health in Nigeria were reviewed. Human activities such as agricultural, industrial and indiscriminate dumping of wastes have been associated with adverse effects on community health, by polluting drinking water, soil, and the air we breathe. Waterborne diseases, cardiovascular diseases and mental disorder are associated with environmental pollutions in Nigeria. The major cause of water, soil and air pollution; forms of pollutions; the associated health risk and mitigating approach to salvage environmental pollution is discussed. Pollution of environment should be of serious concerned to the government and other related pollution agencies. It is therefore recommended that government should ensure that environments are protected from pollutants and unnecessary human activities that could pollute the environments should be checked.*

Keywords: Human activities, pollution, effects, health, Nigeria

CITATION:

Jonah, U. E., Ekpo, I. E., Oribhabor, B. J. and Akpan, I. I. (2023). A Review of Pollution and Its Effects on Community Health in Nigeria. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 523-530

Introduction

Environmental pollution is one of the acts of indiscipline activities affecting the country and a threat to organisms, human health and economic development. Pollution occurs when pollutants and undesirable substances are released directly or indirectly into the environment, resulting in deleterious effects to living resources, hazards to human health, reduction in the standard of living and normal activities of mankind. According to WHO (2018), health is define as a state of complete physical, mental, and social well-being, not merely the absence of diseases or infirmity.

Anthropogenic activities such as agricultural, industrial activities, open defecation and indiscriminate dumping of wastes have devastating effects on the environment, by polluting the water bodies, air and the soil (Manisalidis *et al*., 2020; Jonah *et al*., 2023). Transportation (land), industrialization, agricultural revolution, and rapid urbanization and growth of human population have contributed huge amounts of pollutants into the environment with diverse harmful effects on living organisms including human beings (Miapyen and Bozkurt, 2020; Ukaogo *et al*., 2020**;** Umar, 2020; Pona *et al.,* 2021).

Agricultural lands (soil) in Nigeria have deteriorated, not only due to overuse but as a result of huge amount of fertilizers and agrochemicals used in our soil for crop production to reduce food scarcity, as well as indiscriminate dumping of solid waste and other pollutants into the environment

(Offiong and Edet, 1996). In the Niger delta region of Nigeria, water bodies and the adjoining environments are showing continuous degradation thereby generating more tension within the host communities (Nwilo and Badejo, 2005).

Global warming, an aspect of climate change has resulted in unregulated rise in global environmental temperatures. It is well known that climate change event is as a consequence of human use of fossil fuels and the resultant release carbon dioxide (CO_2) and other greenhouse gases into the atmosphere (Inyinbor *et al*., 2018). These gases in turn trap heat within the earth's atmosphere, accompanied with environmental effects ranging from rising of sea levels to severe weather events (Inyinbor *et al*., 2018). According to WHO (2003), climate change together with anthropogenic activities affect human well-being directly and indirectly. The direct influence is through the physical effects of the climatic conditions while indirect involves the influence on the intensities of pollution in the atmosphere, on water bodies that provide sea food and pathogens that cause infectious diseases (Inyinbor *et al*., 2018). This paper review the impacts of human activities and the accompanying pollution on the environment (water, air, and land) and the associated implications on human health in Nigeria

Sources and Forms of Pollutants in The Environments

Pollutants are substances which when introduced into the environments cause undesirable effects. Pollutants harm our environments either by increasing levels above normal or by introducing harmful toxic substances. The long or short-term effects of environmental pollution generally depend on the nature and the source of pollutants.

Sources of pollutants

These sources of pollutants include:

I. **Point source**: The point source is directly attributable to one influence. It has specific channel through which pollutants get into the environment. When the source of pollution is known, it is easy to control and regulate. Point sources of pollutants include ditch, industry discharge pipe, storm drain, sewage treatment plants, construction sites, oil fields, and leachates from waste disposal systems.

II. **Non-point source**: The non-point source has various ways through which contaminants get into the environment. Such pollutants are very difficult to regulate and control. The main cause of non-point pollution are agricultural activities releasing agrochemicals, nutrients from crops, animals wastes from feedlots; urban runoff, construction site and land disposal, atmosphere, and municipal incineration. (Cunningham *et al*., 2005).

Forms of Pollutants

I. **Oil spill pollutants:** These include oil spill pollutants (polycyclic aromatic hydrocarbons and heavy metals).

II. **Municipal pollutants:** These include chemicals from home and garbage; feces, detergents and waste water.

III. **Agricultural and organic pollutants**: These include pesticides, herbicides, polychlorinated biphenyl dioxins, and veterinary waste**.**

IV. **Radioactive pollutants:** These include radium, uranium, caesium-137 and strontium-90.

V. **Atmospheric pollutants:** These include particulate matter, ozone, carbon monoxide, nitrogen oxide, sulfur dioxide and volatile organic compounds.

VI. **Industrial pollutants:** These include untreated sewage, pharmaceuticals waste, dyes, and thermal effluent. (Cunningham *et al*., 2005; Manisalidis *et al*., 2020).

Health Implication of Pollution on Natural Resources

Implication of water pollution on health

Surface water is the most critical natural resource and important component of the earth. It is regarded as essential in the sustenance of all forms of life (Howladar *et al*., 2021; Jonah and Akpan, 2021). Surface water pollution occurs in both marine and freshwater bodies in Nigeria. Any physical, biological, or chemical change in their natural quality can adversely affects living organism or make it unsuitable for desired uses and this can be considered as pollution (Cunningham *et al*., 2005). Previous studies (Esoka and Umaru, 2006; Ekiye and Zejiao, 2010; Jonah *et al*., 2020; Okoro *et al*., 2020) reported that some water quality parameters (cadmium, chromium, lead, nickel, turbidity, hydrogen ion dissolved oxygen, total dissolved solids,

total suspended solids, phosphate, nitrate etc.) in Nigerian freshwater bodies exceeded standard limits set by World Health Organization, Federal Ministry of Environment and Standard Organization of Nigeria. The authors attributed these to human activities such as sand mining, extraction of mineral resources, agricultural and industrial activities.

The presence of potential toxic elements (PTEs) such as Al, Cd, Cr, Pb, Mn, As, Ni and Cu in drinking water exceeding the standard limit is detrimental to health of children and adults exposed to such contaminated water, due to their highly toxic nature at high quantity. Trace metal pollution (trace level) have become a global problem because of its high toxic and carcinogenic character (Sengupta and Agrahari, 2017) and persistency in the environment with ability to accumulate in the biota (Baghvand *et al.,* 2010; Rajaei *et al*., 2012; Ali *et al*., 2019). Chronic exposure to metallic pollutants from multiple sources have been reported to be associated with various health challenges such as neurological disorder, cancer; cardiovascular, kidney, and bone diseases (Steenland and Boffetta, 2000; Jonah *et al*., 2023).

Human exposure to lead toxicity is known to cause constipation and anemia (Bolger *et al*., 2000), while in children, it causes noxiousness and dysfunction of central nervous system. Higher exposure to Nickel could lead to hypoglycemia, asthma, nausea, headache, and epidemiological symptoms like cancer of nasal cavity and lungs (Rattan *et al*., 2005). People living within the coastal zones are more vulnerable to PTEs exposure through dietary intake of aquatic food resources such as shellfish, finfish, and shrimp which are sources of nutritious food (Astute *et al*., 2022).

However, indiscriminate release of untreated human wastes into drinking water sources is the main source of pathogens (infectious agents), causing waterborne diseases such as typhoid, cholera, amoebic dysentery, enteritis, polio and infectious hepatitis, whose effects are mostly found in children below 10 years in Nigeria (Oguntoke *et al*., 2009). Study reported high prevalence of water borne diseases such as cholera, diarrhea, dysentery and hepatitis in north-west Nigeria (Raji and Ibrahim, 2011).

In addition, chronic exposure to high concentration of nitrate in drinking water is associated with cyanosis and asphyxia in infants less than 3 months, while detergents, pesticides and poly aromatic hydrocarbons are associated with carcinogenic effect or cancer in humans (SON, 2011). Studies (Adeboyejo *et al*., 2011; Adeyemi *et al*., 2011) in Lagos Nigeria reported that pesticides in water were associated with immune systems malfunction, endocrine disruption, breast cancer, dizziness, tremor, and chronic convulsion. Studies carried out in Nigeria had reported industrial effluents discharged directly into the rivers without proper treatment are associated with potential toxic element (Ahmed and Tanko, 2000; Wakawa *et al*., 2008). High phosphate concentrations in these effluents could result into nutrient enrichment of the receiving water bodies thereby leading to ecological disaster; other resultants effects could include water quality impairment, reduction in fish abundance and effect on water-usage for recreation, industrial and domestic purposes.

Implication of soil pollution on health

Soil pollution occurs as a result of the releases of toxic chemicals or the disposal of both solid and liquid wastes, such as heavy metals, hydrocarbons, pesticides, and herbicide into the soil, which could damage the thin layer of fertile topsoil (Alengebawy *et al.,* 2021). The soil is the fundamental source of wealth, as it provides food, and supports diverse means of human existence. When soil is polluted it will definitely affect every ecological service including water, biological and economic sustainability.

Human activities (agricultural, industrial, indiscriminate waste disposal) and the rapid growth of cities have been implicated as the major sources of soil pollution in Nigeria (Ileaunwa *et al*., 2020). Large quantities of human wastes are generated in various households, coupled with improper disposal (Pacheco *et al*., 2018) and in most cities; industries are releasing various forms of liquid wastes into the soil without proper treatment. In addition, poor management in agricultural practices has added more pollutants to the soil, due to consistent use of huge amount of fertilizer in our soil during crop production (Talman *et al*., 2002). These pollutants and other toxics elements in the soil are usually washed into the river, stream, and oceans, including groundwater with subsequent effect on human health especially those drinking from such polluted water (Offiong and Edet, 1996).

Poor sanitation and open defecation into the soil are associated with pathogens and chronic exposure to contaminated soils could be associated with leukaemia in both adults and children (Ileaunwa *et al*., 2020). The polychlorinated biphenyls are associated with neuromuscular obstruction and depression of the central nervous system, headaches, nausea, fatigue, eye irritation, and skin rash (Ileaunwa *et al*., 2020). A study assessing the impacts of oil exploration activities on agriculture and natural resources in Nigeria reported that oil industries activities adversely impacted soil, and other natural resources resulting in food scarcity, lack of good drinking water and poor standard of living (EIA, 2005). The potential toxic elements (PTEs) such as Hg, Cd, Cr, Pb, Mn, Ni, and Ca are added into the soil via these activities (Onyenekenwa, 2011).

More so, PTEs in the soil can accumulate in the tissue of plants in contaminated soil; consumption of such plants cultivated in metal contaminated soil poses health risk associated with cancer disease (Chibuike and Obiora, 2014). Studies by Balkhair and Ashraf, 2016, Singh *et al.* 2018, Alengebawy *et al.* 2021 affirmed that high concentration of heavy metals in the soil resulted in corresponding large concentrations in plant tissue, which results in toxicity to humans when food grown in such soil are consumed. Lo *et al*. (2012) reported lead poisoning in children from one to fifteen year in Zamfara State, Nigeria associated with recycling of used lead acid batteries and gold ore process. In addition, abundant of solid wastes materials such as plastics, nylon, clothes in the top layer of soil could result in poor soil fertility for agricultural use, food scarcity, as well as reduces soil ability to yield food (Jackson and Jackson, 2002).

Implication of air pollution on health

Air pollution is generally the most widespread and obvious kind of environmental pollution. According to World Health Organization (2018), human activities contribute to the leading percentage of public health hazards worldwide, with estimation of about 9 million deaths in a year. In Nigeria various forms of atmospheric air pollutants have been reported, ranging from dust particles, smoke, corrosive gases (sulfur dioxide, nitrogen oxide, carbon monoxide, and methane and non-methane hydrocarbons), suspended particulate matter and other toxic compounds (Yusuf *et al*., 2019). These pollutants are released into the atmospheric air by industrial during fossil fuel burning (Manisalidis *et al*., 2020).

However, vandalized oil pipeline and valves leakage contribute to certain percentage of hydrocarbons and volatile organic chemical emitted from oil industries. Air pollution contributes to various health effects. The health of susceptible and sensitive individuals can be impacted even with low concentration of pollutants in the air (Manisalidis *et al*., 2020). Short-term exposure to pollutants in the atmosphere is closely related to chronic obstructive pulmonary disease while long-term exposures lead to asthma, cardiovascular diseases and cardiovascular mortality (Ojolo *et al.,* 2007). Diabetes is seems to be induced after long exposure to air pollutants (Eze *et al*., 2014). Most industrialized cities in Nigeria such as Kano (Kano State), Port-Harcourt (Rivers State), Warri (Delta State), Abuja (Federal Capital Territory), Ikeja (Lagos State) and Onitsha (Anambra State) have been reported to have several health issues owing to chronic exposure to air pollutants (Ojolo *et al*., 2007; Ana *et al*., 2009; Oguntoke, 2010). Diseases such as sneezing, headache, eye irritation, bronchitis, body weakness, nausea, vomiting, respiratory irritation and skin redness are associated with chronic exposure to higher level of Carbon monoxide (CO) and Sulfur oxide (SO_2) in Lagos and Ogun state, Nigeria (Oguntoke, 2010). Moreover, air pollution seems to have malign health effects of children, such as respiratory, cardiovascular and mental disorder leading to infant mortality and chronic disease during the adult age (Alexander *et al*., 2018).

More so, study affirmed that inhalation of particulate matters in the air are associated with serious health effects (Cheung *et al*., 2011) such as cardiovascular diseases and infant mortality (Kloog *et al*., 2013), respiratory diseases and immune system dysfunction (Kappos *et al*., 2004; Asubiojo, 2016; Tunde *et al*., 2018). The particulate matter is formed in the atmosphere as a result of chemical reactions between the different pollutants. The particles produce toxic effects according to their chemical and physical properties; particle < 10 µm in diameter (PM_{10}) after inhalation can invade the lungs eventually to blood stream (Manisalidis *et al*., 2020). Study reported positive relationship between both short-term and long-term exposure of $PM_{2.5}$ and

acute nasopharyngitis and cardiovascular diseases (Zhang *et al*., 2019). Polycyclic aromatic hydrocarbons (PAH_S) compounds such as benzopyrene, acenaphthylene, anthracene and flouranthene are regarded as toxic, mutagenic and carcinogenic substances (Abdel-Shafy and Mansour, 2016) while volatile organic compounds (VOCs) such as toluene, benzene, ethylbenzene and xylene are associated with cancer in human (Kuma *et al*., 2014).

Measures to Reduce Environmental Pollution in Nigeria

Water: Water pollution can be reduced through the following measures:

- Avoiding the indiscriminate dumping of hazardous substances into the water bodies. This will limit the amount of potential toxic elements and pathogens in the environment.
- Treating sewage and waste by oil and food processing industries in Nigeria before discharging the effluent into the water bodies and the use of organic manure against inorganic fertilizers by farmers.
- Water pollution can also be reduced by constant monitoring of waterways by National Environmental Standards and Regulations Enforcement Agency of Nigeria and Federal Ministry of Environment and the human activities in the water. These will help to ascertain the point at which water is polluted and limit the level of pollutants in the water that could be from human activities.
- Prevention of soil erosion by terracing, contour farming and strip cropping methods. These will help to limit the level of surface run-off accompanied with pesticides, herbicides and other pollutants into the surface water.

Soil: Soil pollution can be reduced through the following measures:

- Practicing proper disposal and collection of solid wastes. This will limit the huge amount of solid garbage in the soil.
- Building recycling plants for wastes and creating awareness on the impact of soil pollution.
- Avoiding dumping of garbage into the soil and avoid burning of pollutant source in the soil. This will help to limit the concentration of heavy metals in the soil.

Atmospheric Air: air pollution can be reduced with the following measures:

- Releasing of poisonous gasses in the air should be prohibited; this will limit the concentration of pollutants such as carbon monoxide, dust, grit, sulphur dioxide, hydrogen sulphide, hydrocarbons and chlorofluorocarbons in the air.
- Treating the waste gases of industries to remove sulphur dioxide and oxides of nitrogen and efficient burning of fuel should be adopted, to reduce the level of carbon monoxide and soot.
- Educating the public on the impacts and consequences of air pollution.

Conclusion

Environmental pollution poses various serious health implications on the community including plants, animals and humans. Pollution of environment should therefore be of serious concern to the government and other related pollution and environmental agencies in Nigeria. Pollution management strategies should be given serious attention by Federal Environmental Protection Agency, National Environmental Standards and Regulations Enforcement Agency of Nigeria in order to save our God given natural environment from devastation. Strict anti-pollution laws including setting limits on the amount of pollutants that may be released into the environments and imposing penalties on those who exceed these limits should be created. Indiscriminate dumping of hazardous garbage into the environments should be prevented. Wastes recycling industries should be established to help reduce the amount of wastes in the environment.

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Soot Pollution In Nigeria: Effects, Prevention And Control

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Abstract: *Soot pollution is a form of air pollution that can seriously harm both the environment and public health. Nigeria is struggling with growing worries over air pollution. This issue is mostly a result of the extensive oil exploration and production activities and rapid population expansion, (Yakubu, 2018), and it is predominant in the Niger Delta region. Other sources of soot pollution include; gas flaring, oil spills, artisanal refineries, coal burning, internal-combustion engines, power-plant boilers, hog-fuel boilers, ship boilers, central steam-heat boilers, waste incineration, local field burning, house fires, forest fires, fireplaces, and furnaces. Furthermore, soot pollution or any other form of pollution has been acknowledged to cause negative effects on the environment and the health of the residents. These effects on human health include; pneumoconiosis, difficulty in breathing, cough, exacerbation of asthma, skin disorders, heart attack, strokes, developmental challenges, reproductive disorders, and consequently premature death. Environmental effects include the degradation of air, water, and soil which causes the migration or death of their habitat, stains on buildings, and food contamination. In conclusion, efforts should be made by the government, voluntary groups, and individual citizens to curb practices that cause soot pollution, Relevant authorities should urgently develop stringent policies to prevent soot pollution, and rules and regulations should be set up by appropriate authorities to check incessant burning and activities that may cause soot pollution and most importantly the government must convert artisanal refineries into modular refineries, as they have filled the clear gap in the need for processing crude oil.*

Keywords: Soot, pollution, prevention, Artisanal refineries, air pollution, environmental effect.

CITATION:
Tombere, R. J., Ajayi, R., Ukpong, K. and John, A. R. (2023). Soot Pollution in Nigeria: Effects, Prevention and Control. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 519-522

Introduction

The incomplete burning of hydrocarbons produces soot, a mass of impure carbon particles (Omidvarborna *et al.,* 2015). The primary cause of airborne soot, which is harmful to both the environment and human health, is incomplete combustion. The fuel must burn at a lower temperature with a slightly lower oxygen supply to produce partial combustion as opposed to complete combustion. Soot, which forms a dark powdery deposit after the fuel burns, is a microscopic particle broken up during combustion.

Soot pollution is an example of air pollution that can seriously harm both the environment and public health. Large amounts of particulate or gaseous pollutants are released into the atmosphere as a result of air pollution, which has a negative influence on the ecosystem, and it is characterized by a rise in atmospheric oxidizing capacity, a reduction in atmospheric visibility, and a decline in the quality of the air in a certain area, (Ewubare and Okadigwe, 2018)When the air contains dangerous components that are distinct from its natural elements and are harmful to both human health and the environment, it is said to be polluted, (Natural

Resources Defense Council, 2018). These substances can be in the form of gases, particulate matter (PM) or even energy such as heat or noise (Godish and Davis, 2015).

The World Health Organization (WHO) reports that air pollution causes 3 million fatalities annually, making it the world's biggest cause of death. In 2012, 6.5 million deaths worldwide, or 11.6% of all deaths, were attributable to outdoor air pollution, (Yakubu, 2017). In Africa, air pollution causes 780,000 premature deaths yearly. This is due to the industry in South Africa and Nigeria, as well as to a lesser extent, fire emissions in Central and West Africa (Bauer *et al.,* 2019). Nigeria is struggling with growing worries over air pollution. This issue is mostly a result of the extensive oil exploration and production activities and rapid population expansion, (Yakubu, 2018). The usage of biomass fuels like firewood, careless burning of trash and vegetation, traffic and industrial emissions, and gas flaring have all been identified as causes of air pollution in the Niger Delta region, which is the centre of Nigeria's oil and gas production. Out of the nine states in Nigeria's crude oil-rich Niger Delta, Rivers State is the region's centre for oil and gas development and as a result, it is increasingly plagued by air pollution issues. Numerous effects of air pollution in Rivers State have been studied, including acid rain and, more recently, soot pollution (Yakubu, 2018). The tiny soot particles (PM2.5) present unusual health risks. Due to their small size, these microscopic particles can enter the bronchiolar tissue and cause oxidative stress, pulmonary inflammation, and potential deoxyribonucleic acid damage when inhaled. (Niranjan and Thakur, 2017). These documented adverse health effects from exposure to soot establish it as a major environmental risk to human health (Whyte *et al.,* 2020). Therefore, it is important to address the recent air pollution on all fronts, taking into account public perceptions, in order to stop the issue from getting worse.

Sources of Soot

There are numerous distinct sources of soot in the environment, all of which are products of pyrolysis in some way. They include;

- Gas flaring: Burning of natural gas in connection with oil extraction is known as gas flaring. Since the start of oil production more than 160 years ago, the practice has endured. It occurs due to various factors, including market and economic limits, a lack of suitable regulation, and a lack of political will. Flaring is a massive waste of a precious natural resource that ought to be either conserved or put to good use, like producing electricity (The World Bank, 2015). Black carbon - more commonly known as soot - is a pollutant that is released by gas flares.
- Oil spill: An oil spill is a type of pollution that occurs when a liquid petroleum hydrocarbon is released into the environment, particularly the marine ecology. Burning of these oil spills can be a source of pollution such as soot.
- Artisanal refineries: This is highly prevalent in Port Harcourt and it is referred to as small-scale crude oil processing or ongoing petroleum distillation that frequently takes place outside the purview of state legislation. This illegal processing of crude oil using local technologies causes air pollution in the form of soot formation.
- Other sources of soot pollution are from coal burning, internal-combustion engines (Omidvarborna *et al.,* 2015), power-plant boilers, hog-fuel boilers, ship boilers, central steam-heat boilers, waste incineration, local field burning, house fires, forest fires, fireplaces, and furnaces.

In response to the soot pollution, the Rivers State Government set up a technical team to generate preliminary air quality data in Port Harcourt (Rivers State Government, 2019). However, the study was limited to only one local

government area and did not assess the perceptions of the local residents, as well as the effect the pollution had on the daily activities of residents. The study, nonetheless, reported the possible causes of the soot to include artisanal refining, emissions from asphalt factories, indiscriminate burning of mixed waste, burning of tyres and vehicular emissions (Rivers State Government, 2019). Although industrial sources were identified (e.g., emissions from asphalt factories), most of the other sources mentioned were due to activities of residents (e.g., artisanal refining, indiscriminate burning of mixed waste, burning of tyres and vehicular emissions). All these in one way or another produce soot which pollutes the environment.

Effects of Soot

Soot pollution has various effects on mankind and the environment.

Health Effects;

- People who are exposed to soot pollution are particularly at risk for pneumoconiosis and other respiratory illnesses. Jinadu in the Guardian mentioned that exposure to soot over an extended period of time can lead to pneumoconiosis. It is the collective term for lung illness brought on by mineral dust inhalation. When people are exposed to soot for an extended period, they start to line the walls of these air spaces (alveoli), which inhibits the usual ability for gaseous exchange. The lungs are made up of microscopic air spaces that allow for healthy gaseous exchange. Patients with pneumoconiosis are more likely to develop other respiratory illnesses such as pneumonia, asthma, and others (Akutu, 2018).
- The tiny soot particles (PM2.5) present unusual health risks. Due to their small size, these microscopic particles can enter the bronchiolar tissue and cause oxidative stress, pulmonary inflammation, and potential deoxyribonucleic acid damage when inhaled, (Niranjan and Thakur, 2017).
- There is a considerable danger that people who have hypertension already and are exposed to soot will end up in the emergency room with congestive heart failure and dysrhythmias.
- It causes cancer: it was discovered that soot carries carcinogens that cause cancer of the blood when carried in the bloodstream, and can also cause lung cancer. Research shows that lung cancer and skin cancers are not only prevalent but higher in Port Harcourt than in Ibadan, as Port Harcourt is the center for crude oil practices. To establish the seriousness of the problem, Yakubu, (2017) explains that inhaled soot penetrates deep into human lungs, thus affecting health chances including acute bronchitis, aggravated asthma among children, heart attack, strokes, and consequently premature death, developmental challenges, and reproductive disorders.
- Exposure to soot causes common health complaints related to air pollution are difficulty in breathing, cough, exacerbation of asthma, and skin disorders, however, extreme conditions can cause death.

Effects on environments

The environment can be seriously harmed by soot.

- Even just the fact that it darkens the air and gives everything a murky appearance raises questions. When that occurs, visibility could get very challenging, even during the day. Soot can land everywhere when it settles. The result is a very unclean environment. The soot would taint buildings, trees, cars, and everything else both inside and outdoors, (Akutu, 2018). It generally degrades the ecosystem and the natural habitat.
- The soil and water deposition could reduce, altering the chemical makeup of the media. Therefore, it renders the soil to be depleted of

nitrogen, and nutrient imbalances in water bodies cause it to become more acidic.

- The diversity of the ecosystem is disrupted by soot pollution.
- It can worsen the consequences of acid rain and also increases global warming.

Prevention and Control

The abundance of soot has become a serious and potentially dangerous health, and environmental issue, and therefore must be controlled to ensure a sustainable and developed environment. This cannot be done only by the government, but by the efforts of individual citizens and non-governmental organizations.

- Artisanal refineries have filled the clear gap in the need for processing crude oil, therefore the government must convert them into modular refineries. The job and income generation challenges that are the catalyst for the emergence of the artisanal refinery will receive substantial attention when this is done. Similarly, to this, oil corporations should implement contemporary best practices, such as the utilization of diversity, to forbid vandalism in their workplaces. This will result in a decrease in crude oil theft, which is the main source of supply for owners of artisanal refineries (Elem, 2021).
- In areas where soot pollution is prevalent, especially in the Niger Delta, the residents should take hygiene seriously. To remove accumulated soot deposits, inhabitants should continually wash their hands before eating, frequently wash their meals, and frequently dust their homes. Their food should also always be covered. To prevent soot from entering their home, they should close all of their doors and windows.
- Protective gear should be worn by those working in industries that expose them to soot, and citizens should
- Government should develop strict policies to control companies involved in activities that cause soot pollution, and develop rules and regulations to prevent the indiscriminate burning of fuels by citizens; The practice of oil industries in waste management and environmental pollution are exceedingly poor and far below international standards (Akinbi, 2012). Despite the existence of environmental laws and regulations such as the Federal Republic of Nigeria's Constitution, the National Oil Spill Detection and Response Agency (NOSDRA) Act (2006), poor monitoring and regulatory control of the oil industry has contributed to an increase in environmental (Sam *et al.,* 2017). Therefore, necessary governmental bodies must ensure compliance with rules, standards, regulations, and prescriptions by these oil industries to curb the menace of soot pollution in the environment, ensuring the use of clean technologies and industrial processes.

Conclusion

It has been deduced in the course of this research that soot pollution is a form of air pollution which tends to contaminate the environment, and water bodies causing harmful effects on the environment and human health, and it is highly prevalent in the Niger Delta as it is the centre for crude oil production. Pollution of the air, water, and soil degrades the environment and poses a threat to a country's development and therefore must be addressed and controlled. Achieving a Nation's development requires a collective effort of individual citizens, non-governmental organizations, and the government itself. Therefore, these three constituencies need to work hand in hand to curb the menace of soot pollution to promote a healthy environment and human development as it is part of the Sustainable development goals.

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Reproductive Health Freedom And Domestic Violence In A Patriarchal Society: Some Findings In Akwa Ibom State, Nigeria

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Abstract: *There is paucity of freedom in the area of reproductive health in patriachal communities which leads to domestic violence. This study looked at the socio-cutural factors and other perculiarities of reproductive health freedom and domestic violence in Ibibioland, South-South Nigeria. With feminism as the theoretical drift, the study utilized interviews and other qualitative methods to elicit data from participants recruited through a multi-staged sampling technique. Simple percentage was the instrument for presentation of socio-demographic statistics of study participants. Emerging data from the largely qualitative work shows that issues of reproductive health freedom and domestic violence mainly border on social power relations against the female gender and cultural worldviews. Since the situation is culturally constructed, the study argues that legal framing and international declarations should be domesticated with vigour. This should be with a view to criminalizing counters to such laws and declartions.*

Keywords: Reproductive, health, freedom , domestic violence and patriarchal society

Citation:

Usoro, N. A. and Brown, A. S. (2023). Reproductive Health Freedom and Domestic Violence in a Patriarchal Society: Some Findings in Akwa Ibom State, Nigeria. IN: Ayandele, I. A.; Udom, G. N.; Effiong, E. O.; Etuk, U. R.; Ekpo, I. E.; Inyang, U. G.; Edet, G. E.; and Moffat, I. (Editors). *Contemporary Discourse on Nigeria's Economic Profile*, A Festschrift in honour of Prof. Nyaudoh, U. Ndaeyo. A. Publication of University of Uyo, Uyo, Akwa Ibom State, pp. 507-517

Introduction

Reproductive health is an important aspect of society's a health system in terms of individuals' ability to have a satisfying and safe sex life, the overall capability to reproduce as well as the freedom of decisions and choices on when and how to do so. Freedom is central to reproductive health, and varies amongst countries around the world. The totality of the right of couples to freely and responsibly decide on the number, spacing and timing of their children and to have information and means to do so is universally acknowledged as a fundamental human right, and domesticated in some countries' national laws. Many scholars and reports (including Usoro *et.al,* 2020; Ononokpono,Usoro and Akpabio*,* 2023 ; Frade,2022 and United Nations Population Fund(UNFPA)/Department for International Development(DFID),2016) specifically added several elements to reproductive rights including the right to legal and safe abortion, birth control, right to education about sexually transmitted diseases, freedom from coerced sterilization and contraception; the right to good quality reproductive health care; the right to information as a basis for making informed choices, among others.

The United Nation's international conference on human rights in 1968 (held in Teheran, Iran) pioneered an effort at recognizing reproductive rights as an aspect of human right: '*parents have a basic human right to determine freely and responsibly the number and the spacing of their children*' (Freedman and Isaacs 1993). The Tehran proclamation was consolidated in Cairo, Egypt in 1994 tagged 'Cairo Programme of Action' at the international conference on Population and Development (ICPD). Paragraph 72 specifically covered a broad range of issues including family planning services, violence

against women, sex trafficking, adolescent health etc. (UNFPA/DFID, 2016)

Reproductive health is a state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity, in all matters relating to the reproductive system and its functions and processes. Reproductive health therefore implies that people are able to have a satisfying and safe sex life and that they have the capability to reproduce and the freedom to decide if, when and how often to be informed [about] and to have access to safe, effective, affordable and acceptable methods of family planning of their choice, as well as other methods for regulation of fertility which are not against the law, and the right of access to appropriate health-care services that will enable women to go safely through pregnancy and childbirth and provide couples with the best chance of having a healthy infant' ((Usoro *etal.*, 2020, Ononokpono,*et.al,*2023 and Frade,2022)).

Subsequent international interest and support for reproductive health included the Beijing Conference (the Fourth World Conference on Women held in 1995) and the Yogyakarta principles in 2006. While the Beijing Conference came out in full support of the Cairo declaration, it went further to broaden the scope of reproductive rights in its declaration as stated in paragraph 96(UNFPA/DFID, 2016)

The human rights of women include their right to have control over and decide freely and responsibly on matters related to sexuality, including sexual and reproductive health, free of coercion, discrimination and violence. Equal relationships between women and men in matters of sexual relations and reproduction, including full respect for the integrity of the person, require mutual respect, consent and shared responsibility for sexual behaviour and its consequences'

Despite this important framework, the country's progress in mainstreaming reproductive health rights in national health policies and legislations remain slow and complicated by factors relating to socio-economic, religion and culture. Acknowledgement is given to the little progress located in wider campaigns on social rights, which have formed the framework for articulating safe and effective contraception, motherhood, universal basic education, gender equality, water, sanitation and hygiene, etc. The patriarchal family arrangements in most countries imply that reproductive freedom and choices are highly limited. Studies have noted several aspects of patriarchal influences on women's reproductive behaviours on issues of sexuality, contraception, timing and the number of children, as well as other choices (Dixon-Mueller 1993, Mason 1987). Women have no autonomy and control over these issues due to cultural limitations as well as poor socio-economic background. Within this context, reproductive freedom mirrors an important aspect of how power relationship is gendered.

To this end, the specific objectives of this paper is to:

(i) interrogates the narratives on attitudes and cultural norms that shape women's decisions on reproductive health and domestic violence in Akwa Ibom State.

(ii) examined the extent of sexual freedom, family planning preferences, and decisions regarding the number of children, among others.

This study attempts a replication of extant findings which situate domestic violence as a serious crime. Theoretically, this work is predicated on the feminist theory which basically seeks changes on behalf of women by focusing on promoting the meeting of the desires, values, and priorities of the feminine gender (Alsop, Fitzsimons, & Lennon, 2002; Edstro & Greig, 2002; Consalvo, 2003; Connell & Messerschmidt, 2005; and Higgens, Hirsch, & Trussell, 2008). Driven by the need to understand the nature of gender inequality, this work acknowledges the patriarchal nature of the

study area and posits the needs to rescript the balance for the betterment of women.

Materials and Methods

The present Akwa Ibom State lies (south-south region) between latitudes 4^0 30′N and 5^0 30′N and longitudes 7^0 20′E and 8^0 15′E. Akwa Ibom land is occupied by three major ethnic groups namely: Ibibio, Annang and Oron. Udo (1983) suggests the Annangs constitute the sub-tribe of Ibibio: '*ethnically…all agree that the Annangs are a branch of the Ibibios. The Ibibios were the majority tribe while the Annangs were the minority tribe'*. Oron people, on the other hand, are the seaborne Ibibios as described by Noah (1980): *'among the sea-borne Ibibio would be included the Oron, Eket and Ibeno who, upon their arrival moved northwards and eastwards until they came up against the eastern Ibibio expanding southwards*'.

Over 80% of the population live in the rural areas; practicing subsistent agriculture and other related businesses such as trades, crafts, commerce, etc. There are over 90% Christian faithfuls among the Ibibios, with some inclinations to syncretic behaviours given the tendency to draw on diverse forms of spiritual and religious sources for medical reasons (Akpabio 2006, 2012).

The Akwa Ibom peoples social and cultural institutions are inherently patriarchal, men generally are in control of every affair in the family and the society at large. Such cultural and institutionalized domination and control exposes women to various forms of oppression and exploitation at every domain including reproductive health decisions and practices. Although women bear the burden of reproduction as well as the primary responsibilities for the day to day management of the domestic affairs, they remain powerless in decisions relating to family planning, sexuality, abortion, sex preferences, the number of children the family should have. Their subordinate position is reinforced by their limited socio-economic background due to some cultural barriers militating against their gaining full access to educational opportunities and participation in major economic occupations as well as occupying key policy and governance positions in the larger society.

Public health services in Akwa Ibom communities remain generally poor, and in most cases characterized by ill-equipped and underfunded infrastructures as well as inefficient management practices. Maternal mortality is high at the rate of 10 percent of the global total (UNFPA/DFID, 2016). Apart from poor infrastructures, women depend on plural sources (from orthodox, faith and tradition) for care at every level of reproductive process. But their freedom to decide when and where to have sex, the number of children as well as issues related to sex education, abortion, safe sex practices and contraception are mostly in the control of their spouses as sanctioned by tradition, religion and customs. In what ways do these practice manifest and how do they affect the reproductive interest of women? This study will address these and related issues among Akwa Ibom people.

In terms of methodological underpinning, this study used interviews, narratives, personal reflections and experiences, discourse, informant sources, and the review of empirical and secondary literature, to understand socio-cultural practices, norms and attitudes influencing women's reproductive health behaviours and decisions in Ibibio land, Nigeria (Izugbara, Etukudoh and Brown, 2005).

Study design

The study adopted a survey design. A purposive sampling was used to select study participants from the headquarters of the three senatorial districts (Uyo, Eket and Ikot Ekpene) of Akwa Ibom State. These Local Government Areas were purposively selected because of the likelihood of having good representation of indigenes of other local government areas within the senatorial

districts. Different techniques of qualitative data collection and analyses were employed in the study.

Study participants were women of reproductive age (18years and above) who were conveniently recruited for the study. The major instruments of data collection were in-depth interview (IDI), Key informant investigation (KII) and community conversation organized among community influencers in the study locale. A total of four (4) community conversations (CC) were conducted. Three of the community conversations were exclusively for women (one in each of the senatorial district), while the participants of the remaining one were both male and female drawn from the three senatorial districts (2 participants from each senatorial district). Each community conversation group in Ikot Ekpene had 8 discussants, Eket had 8 discussants and Uyo was purposively allotted 11, due to its cosmopolitan status as Akwa Ibom State Capital City. Hence, a total of 27 discussants participated in the community conversation.

Data analysis involved thematic organization and analyses of the transcribed responses from interviews and community conversations. Adopting a qualitative inductive approach, specific attention was paid to competing narratives exploring experiences on issues bothering on freedom to decide when and where to have sex, the number of children as well as issues related to sex education, abortion, safe sex practices and contraception are mostly in the control of their spouses as sanctioned by tradition, religion and customs.

For purpose of familiarization, the data was read, and re-read to look for patterns and important issues. Related codes were manually identified, and categorized. The categories were collapsed to form initial themes, which were further refined to make meaningful interpretations of the data.

Results

Descriptive Analysis

This section presents socio-demographic characteristics of study participants.

Table 1: Percentage distribution of participants by education level.

Educational qualification	Participants by gender				Total	%
	Women	%	Men	%		
No formal education	13	48.2 %	0	0%	13	48.2 %
Primary level	4	14.8 %	3	11%	7	25%
Post-primary level	4	14.8 %	1	3.7 %	5	18.5 %
Higher level qualification	0	0%	2	7.4 %	2	7.4%

Gender, age, occupation, income and education were important socio-economic variables considered to be of greater relevance to reproductive health practices in any society. The interview was deliberately targeted mostly at women, hence their high numerical representation (77.8%) over male participants (22.7%). A gendered society in African context concentrates more power of decisions and control in men in relation to women. Consequently, women are more likely to be poorly represented in every facet of social and economic lives. For instance, the educational characteristics of the participants placed women at a very disadvantaged level, with the greater percentage (48.2%) not having formal education, while none of the female participants had acquired higher level of education (Table 1 above) Two categories of occupation were dominant among the participants namely private businesses (44.4%) and Civil service (39.8%). Students constituted 12%, while only one participant (3.7%) said she was unemployed. By gender categories, women were equally poorly represented, perhaps in line with the

cultural norms of patriarchy, that tend to place women at the background.

Table 2: Percentage distribution of participants by occupation.

Occupation	participants by gender				Total	%
	Women	%	Men	%		
Private business	10	37 %	2	7.4%	12	48.2 %
Civil service	7	25 %	4	14.8 %	11	25%
Student	3	11 %	0	1%	3	18.5 %
Unemployed	1	3 %	0	0.7%	1	7.4%

The analysis shows 10 female participants (37%) indicated private business, while 7 female participants (25%) indicated they were Civil servants. Three female participants said they were higher educational level students, while one woman said she had no job. Private business engagements for women could translate to anything including 'no clear employment.

According to a study participant:

> *Some of these women depend on men…nothing to do, but would not tell you they do not have anything doing, this trend has affected to have a say or argue with their husbands on any issue affecting them.*

A further confirmation emerged when one of the female participants who mentioned 'private business' was asked to be specific. It was found out she was engaged in subsistent farming and few other informal trading to support the family. Occupational engagement depends on the location of residence. Women in the rural areas are more likely to be involved in subsistent farming activities that those resident in cities. Of the six men interviewed, four were civil servants while two were into private businesses. In terms of age categories, most of the respondents fell in the age range of 18-30 years (37%) and only one respondent was above 50 years (Table 2)

Household size of respondents' families ranged between 3 and could be as high as 8 members (specifically the number of children per family).

Table 3: Percentage distribution of participants by age.

Age Range (in years)	Respondents by gender				Total	%
	women	%	Men	%		
18-30	9	33.3%	1	3.7%	10	37%
31-40	6	22.2%	3	11%	9	33.3%
41-50	6	22.2%	1	3.7%	7	25%
51 and above	0	0%	1	3.7%	1	3.7%

Three broad reproductive issues were considered including child preferences, family planning and sex education. They are all discussed below:

Child preferences

Twenty-three respondents (85.2%) clearly expressed their preference for male children over the female child. Three respondents (11%) did not indicate any specific preference, while only one respondent (3.7%) mentioned a female child. A further analysis into the statistics indicate that all the female respondents (77.8%) indicated high preference for the male child over the female.

A female participant during IDI aged (30) said:

> *My first child should be a boy…in short I should have male children than females, but that is what the society wants…you secure your marital future by having a male child…my husband wants that…that is what I come to see.*

Another female participant aged (46) added thus during CC:

> *If you don't have a male child in the family, your husband can send you out one day and re-marry…in fact the more male children you have the more you are valued in your matrimonial home.*

Spousal and extended family pressure was popularly cited as the reason, but also friends and neighborhood, '

An elderly IDI participant aged (75) confessed:

Hmmm! No one would regard you in the society if you are a mother of females…you are only regarded and feared if you have many male children…', argued one female respondent who should be in her early 40s. she went on to add as follows: '…here, if you don't have male children, you are likely to be exposed to all forms of ridicules and gossips…any person can walk and insult you scot free…or what of if me or my husband dies, who would inherit the property and who would reproduce the father's name in the family?.

The male respondents all had similar feelings. A close investigation showed the participant who preferred a female child claimed he has 4 children (two males and two females), but his opinion on this was interesting: " I am not too bothered if God gives me a female child…I like female children but you know we need the male children most to carry on the family name and heritage"

Relatively few respondents (11%) were not categorical on their child preferences. However, further discussions indicated their views were not significantly different from the prevailing attitudes of male preference over female children. It was also interesting to note that the respondents' attitudes and preferences were clearly independent of their socio-economic background namely, level of education and exposure. The two male participants with higher qualifications did not deviate in their attitudes and opinions on this topic, as one of them in his early 40s noted:

> My brother, you can't help…this is what the society enforces in our mind…at least you have to have a male child in the family no matter what…it is part of your dignity as a man and a husband…'.

Having a male child in the family is a necessity quite in line with the expectation and norms of the society for reasons of heritage, relevance, continuity and family security. Women have no choice of their own, neither do they have any excuse; the husband, the family and the larger society enforce this practice in every matrimonial homes. The pressure to have a male child from the society is at the root of all forms of reproductive behaviours and practices of most spouses. They resort to churches, faith, spiritual homes, traditional health practitioners and all forms of unorthodox practices to secure their marriage and family with male children.

Popular views during FGD is summarized in this opinion by a male participant:

> *It is so serious that families can go extra length…can do anything in the hands of prophets, pastors, sorcerers…just to have a male child…those who have money can secretly take the option of buying a male child…*

In all cases, the woman is always at the receiving end of accusations of 'curse' 'witchcraft', 'defective womb', and many others, all of which could eventually lead to a divorce. It is a common saying in Ibibio land that the pride of every woman in her matrimonial home is to have children, not only having children, but having male children. Men have options of re-marriage or extra-marital sexual relationship for the sake of having a male child in the home.

Family planning

Family planning here covers the comprehensive approach to the practice of controlling the number of children and the intervals between their births. Family planning is central to reproductive health, and the freedom of choices and decisions in this regard is shaped by the prevailing tradition, religion, customs, attitudes, beliefs and norms of the society. Although family planning practices vary from contexts to contexts depending on awareness level, discussions here were narrowed to the use of contraception, abortion and child spacing practices.

All the female participants held religious and customary views on these issues:

Abortion? No! it is against the will of God…if it happens now, I have no option with me…God will take care…'

Another female participant aged (34) added:

It would depend on my husband…if he agrees and provide money…I could try, but whatever consequences he would bear…I cannot do it on my own…'.

But one female participant aged (45) argued as follows:

'many factors could force one to commit abortion either secretly or with the consent of the husband…if you do not want more children or if the family economy does not support, one can secretly do it without the knowledge of the husband…but sometimes the husband may pretend not to know…'.

Only one male respondent was relatively open in his views of family planning during our discussions as follows*: 'there is no point bringing a child into the world to suffer…I take step to prevent this, and I have to explain to my wife the need…times are hard, so I have to be careful…'*

Similar views were held about child spacing. The idea that children are gift from God was the most frequently use phrase to justify inability to regulate and control child spacing either through contraception or abortion.

As one female respondent aged (40) narrated:

I had my second child almost one year after my first child…when we discovered the pregnancy while still nursing my first child, we could not do anything about it…how do we start, what of if I die in the course of abortion…we decided to keep it…it was real trouble but thank God they are now grown up…come to think of it, if I had aborted the pregnancy, I wouldn't be a proud owner of my second child (a male) (now about 12 years old)…'.

Traditional, religious and moral burdens; a lack of decision autonomy on the part of the woman and the general, traditional attitudes and the absence of appropriate health care infrastructures shape child spacing attitudes and practices of spouses. As children are seen as gift from God, decisions on unwanted, accidental or unplanned pregnancies are often taken with due regard to the moral, religious and traditional considerations: *'it impinges on the consciences of those concerned, and also the fear of losing any possible opportunity of having a child in the nearest future…'*, argued one male informant. The belief that children are special gifts from God implies considerations for such practices as abortion and contraception will be met with negative spiritual repercussions. Traditionally, women have no control of their bodies and reproductive behaviours. Usually in the exceptional cases of the option of abortion or contraception, the overall consent must be secured from the husband to protect the marriage: *'yes, it can lead to divorce if the man has not consented to such practice…your husband would see your action as affront on his position and authority…*' noted one female respondent.

Contraception was also discussed, and the consensus was that women have less power over such practices: *'you can do that without the knowledge of your husband…all depends on the pressure on you as a woman…*' stated one female respondent in her early 40s.

Another woman aged (30) said:

My husband would not want to hear the idea of using condom…he knows he would not be the one to bear the consequences [as in unplanned pregnancy] when it comes…'.

Contraception is one important approach to family planning and reproductive controls. However, women in Ibibio land are presumed not the real owners of their bodies-they are traditionally the properties of their husbands, the family and the community. Invariably, it is the man that controls the reproductive behaviours and choices of his spouse. Women, however devise strategies of coping and controlling their reproductive systems. Friends' network, peer advice and professional

assistance are platforms for coping and engagement*: ''…we depend on patent medicine dealers and other informal itinerant practitioners as well as network of friends for solutions, counselling and services…'',* observed one female respondent in her late 40s. Women draw on these resources to help themselves without the knowledge of their husbands. Several traditional methods were suggested including 'enema with some herbal mixtures', amulets and other traditional contraceptive remedies. Others depend on patent medicine dealers or informal itinerant services. Instances of cooperation with the husbands were equally discussed: *'yes, most husbands understand and can finance such services without direct involvement…times are hard, some husbands do cooperate…*' observed a female respondent in her early 30s. The problem arises when the husband is not cooperating, as any instance of unilateral action by the wife could challenge the stability of such marriage.

Newly wedded couples face difficult challenges on two fronts. While the woman would be aiming to secure the marriage through early procreation, this idea would depend on the cooperation and understanding of the husband. In some cases, the man may be keener on having children than the woman. Under this circumstance, family planning decisions remain a highly sensitive issue: *'the woman would have to be careful as any mistake may endanger her chances of having children in the future as well as the prospect of her marriage…'* argued one male informant. The spiritual belief of the divine origin of children imposes hard choice on the family especially the woman on such issues as abortion, contraception and child spacing. The number of children and the intervals of births do not really matter given the general belief in the generosity of the Creator to provide for their wellbeing. Going contrary to this belief is generally believed could lead to some spiritual punishment including barrenness of the womb.

Sex education

Sex education was another interesting element considered in the fieldwork interview. Sex education cross-cuts every aspect of reproductive health, including: contraception, safe sex, abortion, child spacing and sexuality, among several others. However the question of the right and freedom to discuss and seek appropriate sexual and *reproductive behaviours depend on complex cultural, religious and social factors: 'people are just morally not disposed to discuss such matters except in the secret…the society sees you as a spoilt [morally depraved] child…*' noted one male respondent aged 37. Freedom to participate in sex education is more discriminatory in age: *'girl teenagers rarely cross such boundaries…parents would be concerned that they could barrier their prospects and chances of marriage…'* argued a male respondent. Married women are relatively free to participate in sex education mostly in the secret among their peers and friends.

The outcome of the field interviews demonstrates that the degree of tolerance for participation in sex education is highly gendered particularly against women of different age brackets. Information on reproductive health education is generally secretly guarded against children. At adolescence, sensitivities to reproductive health education and information are moderately high against the girl child. Girls and boys are exposed to limited information on sex education in Senior Secondary school, mostly in Biology and related disciplinary classes, fully complemented secretly through the agencies of peer groups and friends. Such freedom may be relatively possible at adult and under marital relationship in specific contexts through friends' network, professional services and spousal communications: '*yes, at that level a woman may have access to seek and to participate in discussing these things in her interest or when she has a problem or to improve sexual and reproductive wellbeing of the family…but you do*

not do it open less you are labelled as bad [depraved]…' argued a woman respondent in her late 40s. The respondent went on to further state as follows: *'the important issue is don't be open about it, and in some cases, don't allow your husband to see you…'*. The power to exercise freedom of access to sex and reproductive education belongs to the husband (who is traditionally vested with the overall power of discipline including determining the marriage, scolding, beating and other physical and psychological deprivations) at first instance and the society (the power of shaming, discrimination and stigmatization).

Discussion

There is a difference between formal and cultural understandings of reproductive freedom as applicable in Ibibio land. Several issues could be inferred as central to this argument including the notion of the body, the concept of marriage and sex, attitudes around family planning, abortion, sex preferences and the number of children and interval of birth. For instance, the idea that the husband and the community own the woman's body deeply contrasts with the formal notion of the body as a biological/physical entity. Logically, the body (as an important reproductive element of the woman) more or less represents a site of contestation between authorities attempting to inscribe formal notion of reproductive right and the cultural version. For instance, an act of sexual violence committed by the husband against his wife does not qualify as crime (by legal understanding), so also is a case of rape especially against a woman, whose sexual behaviour or orientation is culturally unacceptable.

Two fundamental issues have underpinned the findings of this study, and this mostly border on social power relations and cultural worldviews. Ibibio land is structured on a patriarchal system, with much power (physical, economic, social and cultural) concentrated in males at inter-personal relationship, family, associational and society levels. The power of decisions at the domestic and society levels are highly gendered, so also are the power of discipline and control. The society expects women to subject themselves to their husband, and it would amount to a sign of insubordination if the contrary happens: *'every husband expects submission from his wife…and acting contrary is a sign of impudent…'* argued one female informant. 'Submission' involves everything that belongs to the woman including the body. As one female respondent in her early 40s noted: *'you see, I don't own anything in my husband house…everything is owned by my husband…if I have a salary alert now, I would show my husband and he is the one to decide how the money should be spent…'*. Spousal relationship at family formation mirrors how the larger society is constituted. Men occupy the decision ladder and hold the power of discipline, which keep being reproduced across generations. Such gendered constitution of family and society translates to less power for the women in relation to their spouses.

Cultural worldviews of the Ibibios equally reinforce power inequalities among men and women. Attitudes, beliefs, traditional customs and religious values reflect gender biases, mostly to the detriment of women. Culturally and religiously, women are locked in unequal relationship with men: '*even the Bible supports this…in 1 Peter 3…'* noted a female respondent in her early 40s. The Ibibio traditional religion holds on to a similar belief. Historically, the practice of marrying many wives in Ibibio land was symbolically one aspect of expressing the superiority and power of men over women. In this context, women are expected to be less visible in the public but more active at the domestic arena.

Tradition, religion and customs shape dominant gender-based attitudes and practices of women subordination. This extends to

reproductive health matters. Questions on who owns and control the body have already been explored in different contexts. In south eastern Nigeria Izugbara and Undie (2008) had discussed that the right of woman in some communities is culturally segmented into reproductive right (sexual, reproductive organs and the children born within) believed to be owned by her entire matrimonial community, while the right to her head (life) belongs to her own community of origin. In a related case in Western Brazil, Conklin (2001) argued that people see the body (in Wari community) as a place where personality, community and individuality reside, which constitute the basis for inclusion/exclusion practices involving enemies and loved ones. Traditionally, women do not own and control their bodies in Ibibio land, which forms the entry point for understanding how reproductive health issues are managed. Marriage exists mostly to satisfy the man's desires, needs as well as meeting the expectations of the larger society. In this case, the fertility desires of the husband, family and the entire community override individual freedom and right to sexual health and reproductive freedom. Decisions on appropriate sex behaviours, family planning needs, sex preferences, maternal health and sex education are usually determined by the husband and, by extension, the extended family/the larger society. Funding for family planning needs, maternal healthcare and several other reproductive health issues must be authorized by the husband, while the wife remains a passive recipient. The pressure to have a male child in the family leaves the wife with no choice but to experiment with many children till the desired preference is reached. Such pressure equally carries the prospect of exposing the woman to risky unorthodox options to secure the satisfaction of the husband and the stability of the marriage. Women were noted to be at the receiving end of husband-induced violence at any attempt to resist the sexual urge of the husband. ''*The society frowns at such behaviour…whatever happens to you in the heat of your spouse's anger will be seen as the consequences of your stubbornness, no one cares…''* argued a female informant.

Conclusion

The study has found out that the notion of the body as the entire property of the community is the first entry point for understanding reproductive freedom of women in Ibibio land. Reproductive freedom is understood not within the context of the body as a physical/biological entity owned and controlled by an individual. It revolves around the discourse and conceptualization of the body as culturally embedded and the locus of the construction of sociality. Universally, issues around reproductive rights, including sexual freedom, take the individualist's view of the body as the biological/physical entity, which underpin current universal norms and legal framework as well as the basis for campaigns against sexual violence and rape. Other elements of reproductive freedom including the universally articulated rights (World Association of Sexual Health) around sexual autonomy, integrity and safety; sexual privacy and free and responsible reproductive choices, follow a similar gender-based cultural worldviews. But enforcing these rights and related ones in sub-Saharan Africa is often resisted by entrenched socio-cultural beliefs, attitudes and values.

Recommendations

Since the notions and discourses of reproductive health and freedom in Ibibio land is a cultural construction, this paper argues that legal framing and international declarations should proceed with nuanced understanding of local cultural knowledge and discourses underpinning these issues. Massive and compulsory education of the girl child is advocated in this study as key to capacity building, self-determination and acquisition of other social resources to frustrate

unnecessary suppression and oppression from the opposite sex in the patriarchal setting.

Acknowledgements

We are grateful to the uncommonly bold women who volunteered information for this work. Analysis was supported by Emmanuel Akpabio and the Ibibio Academics Roundtable. Some postgraduate students of the Department of Sociology and Anthropology are also appreciated for interest expressed.

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