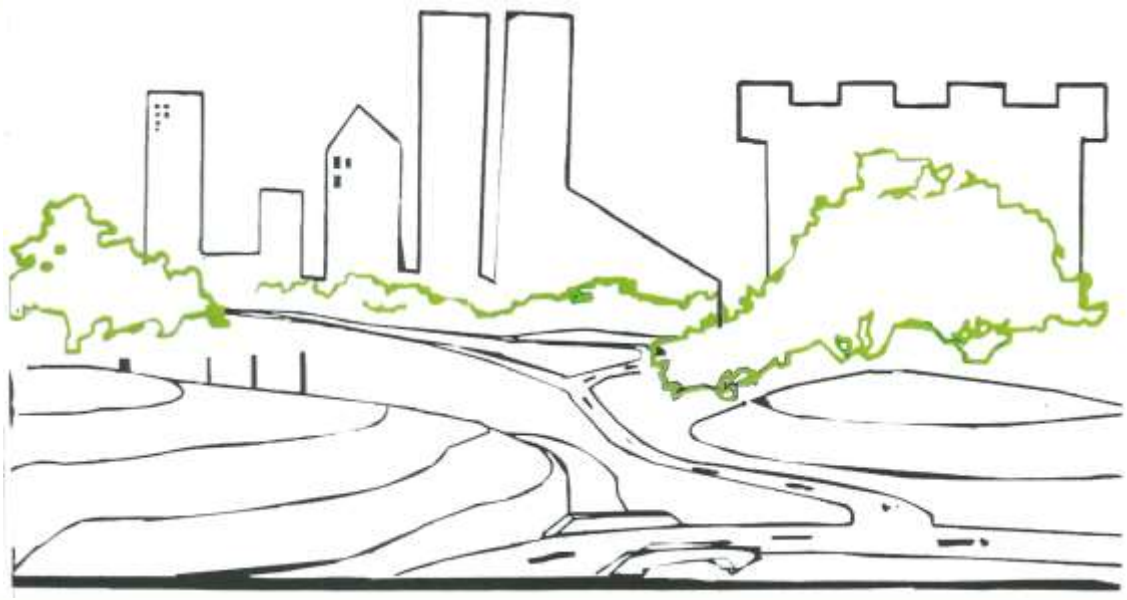
JOURNAL

OF ENVIRONMENTAL DESIGN (JED)

A Journal of Faculty of Environmental Studies, University of Uyo, Uyo, Nigeria
Vol. 18, N0. 2, August, 2023



JOURNAL
OF ENVIRONMENTAL DESIGN (JED)

A Journal of Faculty of Environmental Studies, University Of Uyo, Uyo, Nigeria
Vol. 18, N0. 2, August, 2023

Faculty of Environmental Studies,
University of Uyo, Uyo, Nigeria

Journal of Environmental Design (JED) is published bi-annually by the Faculty of Environmental Studies, University of Uyo, Akwa Ibom State, Nigeria. The Journal of Environmental Design can be assessed online using **University of Uyo website**.

ISSN: 1595-9229-15

Printed in Nigeria by:
Parvenu Technologies
08027228272

EDITORIAL COMMENTS

Welcome to yet another volume of the Journal of Environmental Design. Volume 18 of the JED contains several thought-provoking well researched papers on the various dimensions of the built environment. It must be stated that environmental problems in general have become intricate phenomena requiring a wide range of interests and experts in their planning, management and design. The JED continues in its 18th volume to highlight the works of these experts and presents their informed views and cutting edge research findings for the benefits of policy makers and students of environmental studies. The papers have been peer-reviewed and carefully selected to ensure intellectual balance and intelligent discourse.

The views expressed in the articles published in this Journal (JED) are those of the authors and Journal of Environmental Design (JED) does not hold itself accountable for such.

EDITORIAL COMMITTEE

JED Vol. 18, No. 2, August, 2023

EDITORIAL STYLE GUIDE FOR AUTHORS

Please submit your manuscript double spaced in MS Word, Times new Roman (font 12). **Figures and Tables** should be put in the place where they are mentioned. Maps should be supplied in EPS format. Because manuscripts will undergo a blind review, submit two title pages; the first showing the title of the manuscript, author name, title, affiliation, telephone number, email address and the date of the manuscript. The second title page should contain only the title of the paper. Third-person style is always preferred. If appropriate, authors may make limited use of first-person singular, but a single author should not refer to himself or herself as "we."

Biography: The manuscript should include; on a separate page or the "first" title page described above a sentence listing each author's name, and affiliation.

Abstract: Include a one-paragraph abstract *not exceeding 2*50 *words* and place it on the first page of the text. The abstract describes the issue(s) or question(s) the paper addresses and states the major findings, conclusions and recommendations.

Keywords: To help users reference the JED published research, keywords are included with journal articles. Please suggest at least two keywords for your manuscript.

Abbreviations: The definition of an abbreviation or acronym is given the first time it appears; afterward, only the abbreviation is used. However, an abbreviation that is defined in the abstract should also be defined in the article. An abbreviation that appears only once in an article should be deleted and the full wording used. If an abbreviation is first defined in the text, the abbreviation alone can then be used in subsequent footnotes or tables; however, if the abbreviation is first defined in a footnote or table, the abbreviation should be defined again when it first appears in the following text.

Text Headings: Headings are not numbered and are placed to the left. First-level headings are bold; second-level headings are italicized; and third-level headings are italicized and lead directly into text.

Tables and Figures: Use Arabic numerals to number tables-and figures consecutively in separate series in order of appearance. Include a brief descriptive title at the top of each. **Figures and Tables** should be put in the place where they are mentioned. **Figures and Tables** should be in the body of the work. The text must contain a reference to each table or figure.

Equations: Make sure that all symbols in equations are clear and that all equations (except those in footnotes) are numbered. Single-letter variables should be italicized. Multiple-letter variables, abbreviations (e.g.,AGE) and functions (e.g., expo min. In) should not be italicized neither should be numbered. Parentheses or mathematical operations, vectors and matrices should be in bold (not italicized).

References: The manuscript must include complete and accurate citations of all materials referenced in the manuscript that are not of your original authorship. Please double-check your references to ensure that names and date are accurate, that Web pages are still active, and that there are no discrepancies between the text and the reference list. The APA style is strongly recommended.

TABLE OF CONTENTS

ANALYSIS OF SPATIAL PATTERNS OF URBAN POVERTY IN AKWA IBOM STATE, NIGERIA

Atser Jacob, Inyangmme Usen A. & Itoro Akpan
Department of Urban and Regional Planning,
Faculty of Environmental Studies, University of Uyo, Nigeria
emmaediongmme@gmail.com; jacobatser@uniuyo.edu.ng

Abstract
This study has analyzed the spatial patterns and dimensions of poverty in the urban areas of Akwa Ibom State using multidimensional indicators. The study employed multi-stage sampling procedure for selecting urban communities and households. The first stage was the random selection of communities within 3 kilometer radius of urban areas and the communities constituted the unit areas for data collection. A 10% sampling fraction was applied on the population of 154794 households and a total of 1550 households were considered and utilized as sample size for data collection and analysis. A total of 27 variables of poverty which cut across socio-economic and environmental attributes were utilized. Factor analysis was applied to achieve parsimony in data description as well as to facilitate and isolate the underlying factors defining the patterns and dimensions of poverty. The nine factors which altogether accounted for 78.12% of the total variance in the 27 original variables were regarded as composite indicators defining the spatial patterns and dimensions of urban poverty in the study area and affirms that poverty is a multidimensional phenomenon that cannot be described by a single factor. On the basis of classification, the study revealed a composite score of -0.05 in the dimension of poverty in the urban areas of Akwa Ibom State thus indicating that the State as a whole is within the moderately poor categorization. Further classification of the thirty-one urban areas based on their loadings on poverty profile indicated that 3 urban areas were extremely poor, 11 were very poor, 13 were moderately poor and 4 were poor.
Finally, the study has generated a compendium of baseline data on urban poverty in Akwa Ibom State that can be very useful for the design of poverty policies, and for project intervention by development agencies at both local and international levels. By highlighting those areas that are better-off and worse-off, the study has revealed the extent of commitment of Akwa Ibom State Government in actualizing the objectives of the Sustainable Development Goals (SDGs).
Keywords: *Poverty, urban areas, dimensions, Akwa Ibom, Nigeria*

Introduction

The Government Poverty Alleviation Program should be restructured if not re-designed and should be centered on the 'basic needs' approach. This approach emphasizes the importance of separating generalized increase in income from the more significant attainment of the requirements for a permanent reduction of poverty through the provision of health services, education, housing sanitation, water supply and adequate nutrition. The rationale for this approach was that the direct provision of such goods and services is likely to relieve absolute poverty more immediately than alternative strategies, since growth strategies usually fail to benefit the intended target and the productivity and income of the poor depend in the first place on the direct provision of health and education facilities.

Poverty has remained a threat and challenge to humanity in all ramifications. It is complex, multidimensional and multifaceted with manifestations in the economic, social, political, environmental and every realm of human existence. Poverty encompasses inadequate income and denial of the basic necessities such as education, health services, clean water and sanitation (World Bank, 2007). It is characterized by lack of purchasing power, exposure to risk, malnutrition, high mortality rate, low life expectancy, insufficient access to social and economic services and few opportunities for income generation. Finding ways to reduce poverty has become a daunting challenge for local, national and international decision makers. Anti-poverty initiatives have been traditionally targeted at rural areas, which are presumed to lack more opportunities than urban areas. Ofem and Inyangmme (2013) reported that while rural poverty has been studied since the late 1970s, urban poverty has not received much attention. Olayemi (2013) confirmed that urban poverty has been of low priority on research and development agenda of Nigerian government. That, for over two decades, the agenda has been dominated by rural development and rural poverty.

The recent renewed interest in urban issues has been due to the widespread idea that urbanization is speeding up (Olayemi, 2013). With the increasing rate of urbanization where the rural poor migrate to

the urban areas, the problems of poor city dwellers have become more pressing; including issues of how the urban poor earn their livelihoods, and the ways these affect key indicators of human welfare and the environment for sustainable living. Poverty is therefore associated with individuals or households who are unable to have decent and dignified lifestyles; characterized by inadequate welfare services and social deprivation, low per capita income, overcrowded accommodation, low level of education, low level of capital resources and non-formal sources of capital for business (Ekpo and Uwatt, 2005).
The depth and severity of poverty also indicated a miserable situation. Orokpo *et al*., (2018), mentioned that the rising profile of poverty in Nigeria is assuming an alarming and worrisome dimension. Iheonu and Urama (2019), reported that within Nigeria, data from the Global Consumption and Income Project, GCIP (2019), shows that the rate of poverty overtime has been significantly high. That, in 1960, when the country gained independence, the poverty headcount ratio stood at 61% of the total population, averaging 60% between 1960 and 1970.

From 1971 to 1980, the poverty headcount ratio dropped to an average of about 47%. Based on GCIP data, poverty headcount peaked at 79.6% in the year 2000 and recorded its lowest level in 1997 with a headcount ration of 44.7%. On average, between 1960 and 2015, poverty headcount in Nigeria was 61.8% of the population. In recent times, based on the poverty line of $1.90 per day, 46.5% of Nigerians are extremely poor, with the World Poverty Clock naming Nigeria, 'the poverty capital of the world'. According to the World Data Lab (2019), extreme poverty in Nigeria is increasing by almost six persons per minute. In 2018, according to National Bureau of Statistics (NBS) Nigeria overtook India as the country with the largest population living in extreme poverty. It reported that 40.1% of the population in Nigeria lived in poverty, which equals about 83 million people, (NBS, 2020). Abiola and Olaopa (2008), stated that the scourge of poverty in Nigeria is an incontrovertible fact which results in hunger, ignorance, malnutrition, disease, unemployment, poor access to credit facilities and low life expectancy as well as a general level of human hopelessness. Nwaobi (2003), asserted that Nigeria presents a paradox because the country is rich but the people are poor. However, Orokpo *et al.,* (2018), perspicuously remarked that Nigeria has witnessed a monumental increase in the level of poverty.

The depth of poverty is greater in sub-Sahara Africa than elsewhere in the world. Addae-Korankye (2014), reported that the poverty situation depicted country variations with countries like Uganda, Mali, Nigeria, Zambia, Niger, Madagascar, Zimbabwe, Burundi and Rwanda having more than 50 percent of their population living below $1 a day in 2002. According to Lain and Vishwanath (2021), Nigeria is home to the largest number of poor people in sub-Sahara Africa. The use of socio-economic indicators like per capita income, life expectancy at birth (years), access to health care services, access to safe drinking water, access to education and access to sanitation facilities also depict the extent of poverty in Sub-Saharan Africa. Alkire *et al.,* (2016), found that the majority of the poor do not live in low income or fragile states. It was discovered that over 70% of the poor live in middle income countries, whether the poor are identified in terms of monetary or multidimensional poverty. However, low income and fragile states typically have higher rates of poverty and a greater severity or intensity of poverty than stable middle income countries.

The high levels of poverty and the apparent inability of most underdeveloped economies to address their associated problems prompted the development of an integrated world approach (Wang, 2016). The approach was anchored in the Sustainable Development Goals (SDGs) which have indicators ranging from halving extreme poverty, increasing access to safe drinking water, halting the spread of preventable diseases to providing basic education by 2030. With about 40% of the SDGs target groups living in the urban areas and considering the fact that almost all of the SDGs period have already been spent, spatial analysis of level of poverty among urban households is indeed very significant at this point in time. Kisiała and Racka (2021), reported that more than half of the world's population lives in cities, and this rate is expected to rise to 60% in the next 10 years. Rapidly progressing urbanization processes have a huge impact on the natural environment. Therefore, there is the need for proper spatial planning, creating conditions for economic progress and social development.

One of the most important challenges is the spatial heterogeneous characteristics of poverty in most countries (Hennigner and Snel, 2002), and further submitted that poor people tend to be clustered in

specific places. In line with this understanding Glasmeir (2002), stated that poverty is inherently a spatial problem. He stated that the physical environment could not be disregarded as a factor affecting poverty condition of places and of the people living in disadvantaged regions. Therefore, poverty analysis should adopt a spatial approach because poverty has a spatial dimension. Milbourne (2004), reported that some key poverty materials focused largely on the social components of poverty through analyses of headline national statistics, with relatively little attention given to its spatial characteristics. This becomes more worrisome despite the spatial emphasis on poverty initiated by Charles Booth as early as the 19th century (Vaughan *et al.,* 2005). Although there is a growing literature which addressed neighborhood effects, proximity and spatial patterns and processes in the social and environmental studies, less work is available on these topics in studies of poverty (Hyman *et al.,* 2005).

The development of Geographic Information Systems (GIS) together with advances in remote sensing has taken the leap to incorporating spatial data and satellite imageries suitable for poverty analysis (Hyman *et al.,* 2005). GIS was also found to be useful in highlighting geographic variations of poverty and simultaneously displaying different dimensions and understanding its determinants at disaggregated level. This has in turn allowed visual comparisons of its multidimensional characteristics and provided an avenue for analyzing spatial patterns and its determinants. Such a technique is known as poverty mapping – the spatial representation and analysis of indicators of human well-being (Davis, 2003). In other words, poverty mapping is becoming a new trend today, which is made possible with GIS and remote sensing. Therefore, the initial task faced when developing a plan requires a general description of the problem of urban poverty followed by the identification of its components (de Pérez, 2007). de Pérez (2007) further enunciated that identified components can be mapped in different layers and further combined to determine grades of poverty. Also, a visual analysis using maps is fundamental to understanding the levels of poverty, not only by governmental agencies, but also by the communities involved in the process. Visualizing the problem through maps is a practical way of explaining the problem to community leaders and stakeholders. These leaders, once provided with a full understanding of the government interventions, are more likely to get involved and participate in supporting the plan promoted by city managers.

Although, urban poverty issues are beginning to gain prominence in both public and national discourse in Nigeria, there are no enough deliberate and determined efforts to spatially study it by delineating the phenomenon for policy formulation. Despite recent advancement in modern technologies in the study of spatial pattern of activities and environmental actions, little has been done to study the spatial aspects of poverty in developing countries particularly in Nigeria. More often than not, poverty analysis in Nigeria resides within the economic and policy realms which do not emphasize so much on its spatial dimension. Although there were a few poverty mapping initiatives over the past few years, GIS was mostly used for the production of various poverty maps by plotting various socio-economic indicators and not for spatial analysis (Ofem and Inyangmme, 2013). Given the current agenda espoused in the Sustainable Development Goals (SDGs) of the United Nations aimed at sustaining the gains of the MDGs on the eradication of extreme poverty and hunger; and the capability of GIS to incorporate spatial variables in poverty analysis, it is extremely important, timely and relevant to explore the spatial aspects of poverty conditions in Nigeria, especially the urban areas of Akwa Ibom State in order to improve the targeting of government's poverty alleviation programs. The incorporation of planning dimensions to the understanding of the prevailing urban poverty conditions can significantly enrich the understanding of the spatial units where poverty is deep and severe. This is because the influence of striking locational peculiarities and articulate cultural proficiencies could significantly provide insights into the nature and severity of poverty in the urban areas.

Identifying the poor is a gap in knowledge that must be closed for us to make significant progress in targeting the poor for the purpose of implementing poverty alleviation/eradication programs. Policies and programs intended to help the poor cannot succeed unless the Government and other stakeholders know where the poor are located, the pattern exhibited and how they are likely to respond to different growth strategies. Thus, providing information on the spatial heterogeneity of poverty can greatly assist stakeholders in trying to tackle the challenge of identifying the indicators of poverty in order to help

government and other agencies focus on alleviating the poverty scourge. This problem is what this research seeks to address.

Indicators of Rural/Urban Poverty

According to Alkire and Santos (2014), and World Bank (2018), poverty indicators in developing nations include: lack of access to basic needs or services to the vast majority of people, inadequate access to productive resources like education, enhanced working skills, socio-economic capacity and political rights to participate in decision-making affecting people's conditions of life. They established that health dimension has lack of basic nutritional food and child mortality as indicators of poverty; on educational dimension - the number of years in school and the school enrolment/attendance; and on standard of living dimension factors such as lack of electricity, lack of access to cooking fuel and assets such as non-ownership of radio, television, motorbike, refrigerator and cars/truck constituted indicators of poverty. World Bank (2010), stated that poverty may also manifest in weaknesses and inadequacies of infrastructures, technology and credit facilities to the largest number of people, complete deprivation or exclusion of the vast majority of people from participating in socio-economic and democratization processes.

The Nigeria Poverty Profile 2010 showed that the scourge of poverty goes beyond mere measurement of a household's expenditure or welfare. Poverty has many dimensions and these include inadequate access to government utilities and services, environmental issues, poor infrastructure, illiteracy and ignorance, poor health, insecurity, social and political exclusion. In urban areas, the burden of demand of services has effects on school enrolment, access to primary health care, growth of unsanitary urban slums. Also in rural areas, poverty manifests itself more in the agricultural sector and food security. For any meaningful economic growth and poverty reduction, there is the need to enhance and improve access to social services, including health and education. Thus, the nature and trends of incontrovertible poverty in Nigeria is on the increase and can be seen as essentially structural or chronic with prolong and persistent or permanent deprivation of productive resources and skills for self-expression and self-actualization. Vast majority of people are therefore materially, psychologically incapacitated or permanently endangered.

Elhadary (2011), also identified poverty indicators to include: economic consumption and income, head count index, poverty gap; productive assets: housing, caloric intake to requirement, children's weight-for-age, sanitation and water, access to safe drinking water and morbidity due to water-borne diseases. Energy assets include access to electricity/fuelwood, nutritional or educational indicators, health and family planning, access to primary healthcare, infant mortality rates, education, primary school enrollment rate, literacy rates, enabling environment, access to opportunities, access to land, credit; participation in decision making. The productive assets are income from agricultural surplus or non-farm activities, natural endowment, agro-climatic variables, measures of agricultural productivity and food security, geographic infrastructure, access to markets, and volume of income from sales of agricultural surplus.

In a study conducted by UNDP (2004), on Poverty Reduction and Economic Recovery in Somalia, the following were identified as Possible Core Poverty indicators: proportion of population living below the poverty line: number of people or households living in absolute poverty; dependency ratio, Gini coefficient, consumption per capita of poorest 20 percent, per capita, GDP saving/GDP ratio; proportion of households negatively affected by civil disturbance and violence, number of people internally displaced, number of civilian deaths resulting from civil conflict, proportion of households experiencing major food poverty as a shock in a given period, refugees and displaced persons as proportion of district population, proportion of households on Zaket area not serviced by roads; adoption rates of modern farming methods, yield rates, percentage of farmers growing food security crops; availability of markets by type, accessibility of markets, volume of goods and services handled at a given market; unemployment rate, average hours worked per day; proportion of population accessing micro-credit, growth in savings, and availability of micro-finance services.

Based on the UNDP Somalia study, much of the data on key poverty indicators in Somalia is summarized in the Human Development Report (HDR) 2001, and the Socio-Economic Indicators

Report- 2002. However, the indicators of great interest are those on income poverty, human poverty, life expectancy, vulnerability, infant/child/mother mortality rates, educational attainment, and literacy/numeracy, access to essential services (health, water, sanitation etc); food security, nutrition, household food economy, unemployment, accessibility to public and private health facilities, household assets, levels of parents' education and nearness to clean drinking water etc.

Esin (2015) identified spatial indicators of poverty to include: water sources, household energy, and predominant mode of transport, waste disposal facility, clothing quality, and household furniture, ownership of electronic devices, household communication device, and ownership of alternative power generators. He further identified more indicators to include ownership of business enterprise, access to credit facility, sources of credit facility, monthly expenditure on food, monthly expenditure on education, monthly expenditure on clothing, monthly expenditure on transportation, monthly expenditure on health, meals/feeding per day, nature of building. Other indicators were nature of floor, nature of walls, number of household with toilets, nature of toilet, nature of bathing facility, number of rooms occupied by household, nature of kitchen, tenure of housing units, and occupation of household head. In his study, Yusuf (2008) identified major poverty indicators to include unemployment, amenity problems, poor harvest, low level of material wealth, illiteracy, inaccessibility to modern health services and poor diet. Others are helplessness, powerlessness and inability to fulfill social needs which are non-material aspects of poverty and deprivation that increases social vulnerability. From the above review, it is evident that most poverty indicators studies are based on parameters considered at the national and international scales. There are only a few attempts to look at poverty indicators at the lower scales of our urban populations.

Study Area and Methodology

Akwa Ibom State of Nigeria is located at the south-east corner of Nigeria (Figure 1) between latitudes 4^{o} 3′and 5^{o} 32′ North and longitudes 7^{o} 25′ and 8^{o} 30′ East. It is bounded on the north by Abia and Cross River States. On the south, the State is bordered by the Atlantic Ocean and on the south-west and west by Rivers and Abia States respectively. Akwa Ibom State has a landmass of 8,412 square kilometers (Akwa Ibom State, 1989). The State, which was created on 23rd September, 1987 from the former Cross River State, Nigeria, is administratively divided into 31 Local Government Areas (LGAs) including Uyo, the State capital city. By this division, the State has legally or administratively established 31 urban areas as headquarters of the LGAs with Uyo, Eket, Ikot Ekpene, Abak, Etinan, Itu, Ikot Abasi and Oron being the oldest and most developed urban settlements. This is shown in Figure 1. According to Tharenou *et al.*, (2007) research design is the overall plan or structure used to answer research questions. It describes the major procedure to be followed in carrying out the research (Ogolo, 2012). The data requirements which cut across socio-economic and environmental attributes were related to some identified measurable indicators and determinants of poverty among the urban households in the study area. Twenty-seven (27) variables as indicators of poverty were utilized as shown in Table 1.

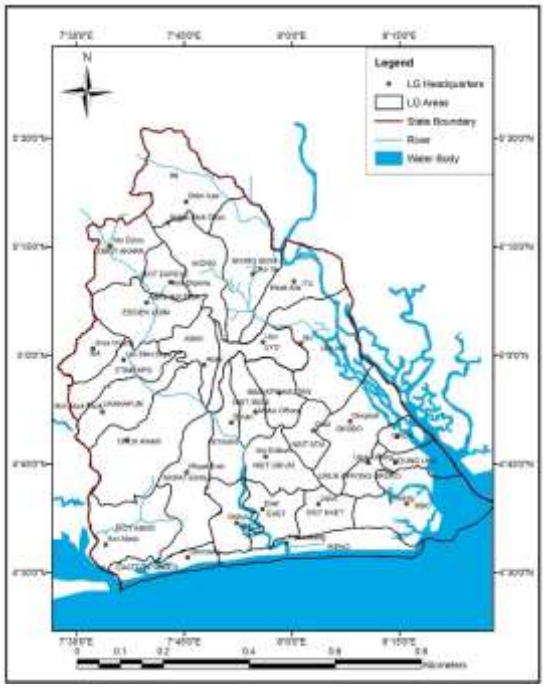


Figure 1: Location of Urban Centres on the Map of Akwa Ibom State.

The population of study comprised all settlements within the three (3) kilometer radius of the thirty-one (31) Local Government Headquarters designated as urban areas in the State. The population was determined using the 1991 National Population Commission census and projected at an annual growth rate of 3.0% for 2022. This gave a projected population of 1128885 persons. The 1991 population census was preferred to the 2006 data because it has sufficient and detailed information about settlements in terms of their individual population figures. Using a systematic sampling technique, 10% of the total number of the settlements was selected in each urban area in the State. The various communities within the 3 kilometer radius and their populations were merged into one as an urban area in each Local Government Area. Udofia (2011) asserted that, one method for determining minimum sample size is by the use of sampling fraction. This is the ratio between the size of the sample and the size of its parent population. A 10% sampling fraction was deemed satisfactory. In this study therefore, 10% of the total number of settlements making up sampled LGAs were selected for the survey using table of random numbers.

Table 1: List of dependent variables and units of measurement

s/n	Indices	Unit of Measurement	Data	Sources
1	Water sources	Type	Ordinal	Rijberman (2003); Nyambod and Nazmul (2010)
2	Household energy	Type	Ordinal	Broto et al (2016)
3	Predominant mode of transport	Type	Ordinal	Gannon and Liu (1997); Booth et al (2000)
4	Waste disposal facility	Availability	Ordinal	Billah (2007); Essien et al, (2012)
5	Household furniture	Number	Ratio	Campbell(2015)
6	Electronic devices	Number	Ratio	Gomez-Arbelaez et al, (2014)
7	Household communication device	Number	Ratio	Dumund et al,(2016)
8	Alternative power source	Type	Ordinal	Bowora and Chazorachii(2010), Pigato (2001)
9	Business enterprise by H/members	Type	Ordinal	Lawanson and Olanrewanju (2012);
10	Access to credit facility	Type	Ordinal	Beall and Kanji (2005); Menda (2015)
11	Sources of credit facility	Type	Ordinal	Okurut (2005); Akinbode (2013); Mujeri (2015)
12	Monthly expenditure on food	Naira	Ratio	Agbaeze and Onwuka (2014)
13	Monthly expenditure on education	Naira	Ratio	Babalola and Isitor (2014)
14	Monthly expenditure on clothing	Naira	Ratio	Camerons (2012), Odior (2014), Tilak(2000)
15	Monthly expenditure on transport	Naira	Ratio	Dhasmana and Mukheijee (2014)
16	Monthly expenditure on health	Naira	Ratio	Kumarage (2007), Titheridge et al, (2014)
17	Meals / feeding per day	Number	Ratio	Kamau et al, (2011);
18	Nature of building	Type	Ordinal	Mohiddin et al, (2012)

19	Nature of floor	Type	Ordinal	Cohen and Garrett (2009)
20	Nature of wall	Type	Ordinal	Hardoy and Almansi (2011)
21	Number of household with toilets	Number	Ratio	Hardoy and Almansi (2011); Blake et al, (2007)
22	Nature of toilet	Type	Ordinal	Biran and Jenkins (2010),
23	Nature of bathing facility	Type	Ordinal	Osumanu et al, (2016)
24	Number of rooms occupied	Number	Ratio	UN-Habitat (2011)
25	Nature of kitchen	Type	Ordinal	Hardoy and Almansi (2011)
26	Tenure of housing unit	Type	Ordinal	IHD (2012)
27	Household head major occupation	Type	Ordinal	WCR (2016)

The study employed multi-stage sampling procedure for selecting the representative settlements and households. The first stage was the random selection of settlements within 3 kilometer radius from the center of the headquarters in the thirty-one LGAs in Akwa Ibom State. These settlements constituted the unit areas for the study. The projected population was converted into number of households by dividing the population by 6 which is the average household size for Akwa Ibom State. A 10% sampling fraction was applied on household population of 154794 number of households and a total of 1550 number of households was considered and utilized as sample size with household heads as respondents for the purpose of data collection and analysis.

Table 3: List of settlements studied with their 2018 projected populations and sampled size

S/N	LGA	Settlements (Aggregated)	1991 Pop	2022 Projected	H/holds	Sample size
1	Abak	Abak	18062	34320	4902	50
2.	Uyo	Uyo	218355	414934	59273	50
3	Ibesikpo/Asutan	Nung Udoe	14887	16012	2286	50
4.	Nsit Ibom	Afaha Offiong	12601	23944	3419	50
5.	Etinan	Etinan	21818	41459	5922	50
6.	Mkpat Enin	Mkpat Enin	6202	9205	1682	50
7.	Oruk Anam	Ikot Ibritam	6237	11851	1691	50
8	Ikot Abasi	Ikot Abasi	10568	20081	2868	50
9.	Eastern Obolo	Okorote	3302	6274	895	50
10.	Onna	Abat	23105	43903	6269	50
11.	Eket	Eket	49019	89348	12761	50
12.	Esit Eket	Uquo	10704	20340	2905	50
13.	Mbo	Enwang	5882	11176	1595	50
14	Udung Uko	Eyofin	2013	3825	546	50
15.	Oron	Oron	14209	27000	3856	50
16.	Obot Akara	Nto Edino	1096	2082	297	50
17.	Okobo	Okopedi	14285	27143	3856	50
18.	Nsit Atai	Odot	2021	3839	548	50
19.	Nsit Ubium	Ikot Edibon	6431	12220	1745	50
20.	Uruan	Idu	6834	13004	1857	50
21.	Itu	Mbak Atai	3475	6603	734	50
22.	Ibiono Ibom	Oko Ita	4297	8163	1165	50
23.	Ikono	Ibiaku Ntok Okpo	3004	5707	814	50
24.	Ini	Odot Ikpe	1229	2335	333	50
25.	Essien Udim	Afaha Ikot Ebak	7084	13461	1922	50
26.	Ika	Urua Inyang	2793	5307	757	50
27.	Etim Ekpo	Utu Etim Ekpo	6200	11780	1681	50
28.	Ukanafun	Ikot Akpa Nkuk	9151	17387	2482	50
29.	Ikot Ekpene	Ikot Ekpene	87760	166768	23822	50
30.	Ibeno	Upenekang	16831	31982	4547	50
31.	Urue Offong/Oruko	Urue Offong	3164	6012	858	50
	Total		594,079	1,128,885	154,794	1550

Factor analysis as a multivariate statistical technique was applied in research to achieve parsimony in data description as well as to facilitate and isolate the underlying factors defining the patterns of poverty. The model also helps to achieve frugality in data description, and assumes that all extracted factors account for the variation in the phenomena that is being explained. The factor analysis model is expressed as follows:

$$X_1 = b_{11}f_1 + b_{12}f_2 + b_{13}f_3 + \ldots\ldots\ldots\ldots\mu_1 + \epsilon_1 \quad \ldots\ldots\ldots\text{Equation 1}$$

$$X_2 = b_{21}f_1 + b_{22}f_2 + b_{23}f_3 + \ldots\ldots\ldots\ldots\mu_2 + \epsilon_2, \text{ etc} \quad \ldots\ldots\ldots\text{Equation 2}$$

Where: μ_1 = the mean of X_1; ϵ_1 = the residual specific to the ith test after taking account of the contribution of the factors; f_1, f_2, f_3 = the value of the factors which vary from one subject to another but have zero mean and unit variance, and are assumed to be uncorrelated with one another and with the residuals; bif=constants, like regression coefficients, indicating how much that is affected by each factor. The result of the analysis therefore produced the factor scores which expressed the patterns and dimensions of poverty.

Patterns and Variations of Poverty Indicators among Urban Households in Akwa Ibom State

This study sought to identify where the poor are located in the urban areas of Akwa Ibom State. To achieve this objective the result of the factor analysis of twenty-seven (27) poverty indicators as collected from 31 urban areas of Akwa Ibom State is presented in Table 4. From the Rotated Factor matrix, it could be observed that the factor analysis procedure using Verimax with Kaiser Normalization rotation yielded a nine-dimensional solution. The communalities, which are regarded as indications of the importance of the variables in the analysis are generally high (above .50). This shows that the variables selected for this study were appropriate and relevant. The nine factors which altogether accounted for 78.12% of the total variance in the 27 original variables may be regarded as composite indicators defining the spatial pattern of urban poverty in the study area. This affirms that poverty is a multidimensional phenomenon that cannot be described by a single factor (Coudouel *et al*, 2002). The thirty-one urban areas were therefore classified based on their loadings on each of the factors with the application of the matrix of factor scores to determine the spatial pattern of the poverty levels in the area.

Factor 1 accounted for 21.10% of the total variance within the distribution of poverty variables and is without doubt the most important factor. Of the twenty-seven variables in the analysis, six of them loaded positively and significantly on this dimension. These include:
Y1 - Water sources, 0.844
Y7 – Communication device, 0.636
Y21 – Number of household with toilets, 0.549
Y22 – Nature of toilet, 0.515
Y24 - Number of rooms occupied, 0.796
Y26 - Tenure of housing units, 0.642
These variables are associated with the management of the environment which the poor are often identified as living in slums and unkempt environment. The factor is called "Environmental Sanitation/Housing Needs Factor".

Factor 2 accounted for 14.29% of the total variance. This factor has strong relationship with involvement of the urban residents in business venture and preservation of household assets in the area. The Factor 2 is called "Asset Factor".
Associated with this factor are four variables of:
Y9 – Business enterprise, 0.578
Y15 – Monthly expenditure on transportation, 0.537
Y18 – Nature of building, 0.783
Y25 – Nature of kitchen, 0.678

Factor 3 was found to account for 9.16% of the total variance in the original data matrix. This factor is related to the wellbeing of the residents; therefore, it is referred to as "Wellbeing Factor".
These variables loaded highly on four variables which include
Y14 – Monthly expenditure on clothing, 0.671
Y15 – Monthly expenditure on transportation, 0.557
Y16 – Monthly expenditure on health, 0.555
Y27 – Occupation of household head, 0.631

Factor 4 accounted for 8.09% of the total variance and had three variables loaded positively and significantly. This factor identifies with generating funds so as to cushion the economic instability of the residents. So the factor may be named, "Credit/Food Security Factor". These were:

Y11 – Sources of credit facility, 0.913
Y12 – Monthly expenditure on food, 0.736
Y23 – Nature of bathing facility, 0.497

Factor 5 accounted for 6.73% of the total variance. The factor has more loading on devices that are used by the households in the study area and is named "Electronic Devices Factor".
Y6 – Electronic devices, 0.532
Y14 Monthly expenditures on clothing, 0.438

Factor 6 was found to load highly on two variables and accounted for 5.47% of the variation within the distribution of poverty variables. It is called "Household Facilities Factor" because it has to do facilities that households in the area have.
Y5 – Household furniture, 0.555
Y8 – Alternative power source, 0.857

Factor 7 accounted for 5.06% of the variation within the distribution of dependent variables and is named "Basic Needs Factor" because it loaded high on
Y6 – Electronic devices, 0.534
Y17 – Meals/Feeding per day, 0.703
Y21 – Household with toilets, 0.674

Factor 8 accounted for 4.35% variation in the original primary variables. The factor seemed to represent the energy status of the respondents and also education expenditure. It is called "Education/Energy Factor". It loaded positively and significantly on
Y2 – Household energy, 0.700
Y13 – Monthly expenditure on education, 0.799
Factor 9 accounted for 3.87% of the total variance. The factor is associated or related to building quality. It is named, "Building Quality Factor". Three variables loaded positively and significantly on
Y19 – Nature of floor, 0.531
Y20 – Nature of walls, 0.830
Y26 – Tenure of housing units, 0.503

Table 4: Rotated factor matrix for the distribution of poverty indicators in urban areas of Akwa Ibom State

S/N	Variables	F1	F2	F3	F4	F5	F6	F7	F8	F9	Communalities
1	Water sources	.844									**.807**
2	Household Energy	.372	-.324						.700		**.835**
3	Predominant mode of		.466		-.312	.383					**.710**
4	Waste disposal facility			-.775			.313				**.796**
5	Household furniture					.303	.555		409.	.326	**.729**
6	Electronic devices					.532		.534	.396		**.778**
7	Communication	.636							.421		**.726**
8	Alternative power						.857				**.776**
9	Business enterprise	.349	.578								**.550**
10	Access to credit					-.794					**.666**
11	Sources of credit				.913						**.917**
12	Expenditure on food				.736	-.459					**.838**
13	Expenditure on								.799		**.746**
14	Expenditure on			.671		.438					**.866**
15	Expenditure on		.537	.557							**.817**
16	Expenditure on health		.454	.555		.389					**.748**
17	Meals/feeding per day		.303					.703			**.763**
18	Nature of building		.783								**.777**
19	Nature of floor	.482				.317		.343		.531	**.883**
20	Nature of walls									.830	**.829**
21	Household with toilets	.549						.674			**.841**

22	Nature of toilet	.515			.473		.374				**.811**
23	Nature of bathing facility	.469	-.392		.497		.406				**.848**
24	Rooms occupied	.796									**.708**
25	Nature of kitchen		.678				-.314	.370			**.803**
26	Tenure of housing	.642		.314						.503	**.816**
27	Occupation of h/hold			.631				.369			**.708**
	Eigen value	**5.698**	**3.859**	**2.473**	**2.184**	**1.818**	**1.477**	**1.366**	**1.173**	**1.044**	
	Percentage of	**21.10**	**14.29**	**9.16**	**8.09**	**6.73**	**5.47**	**5.06**	**4.35**	**3.87**	
	Cumulative	**21.10**	**35.40**	**44.55**	**52.64**	**59.37**	**64.84**	**69.90**	**74.25**	**78.12**	

F1 – Environmental Sanitation/Housing Needs Factor, F2 – Asset Factor. F3 – Wellbeing Factor, F4 – Credit/Food Security Factor, F5 – Electronic Devices Factor, F6 – Household Facilities Factor, F7 – Basic Needs Factor, F8 – Education/Energy Factor, F9 – Building Quality Factor

Variation in Spatial Pattern of Urban Poverty

The distribution of factors of urban poverty provided the means of identifying the variation in the spatial pattern of poverty using specific variables in the area. This was measured using the factor scores for the urban centers on the nine dimensions as extracted from factor analysis. This is shown in Table 5.

Table 5: Dimension and spatial Patters of Poverty in Akwa Ibom State

S/N	Urban Areas	Dimension and spatial Patters of Poverty									
		F1	F2	F3	F4	F5	F6	F7	F8	F9	**Total**
1.	Ibiaku Ntok Okpo	0.50	-1.85	-0.98	0.20	-0.80	0.61	1.85	-0.57	0.53	**-0.51**
2.	Etinan	0.26	-0.66	-0.60	-0.24	-0.61	-0.38	0.13	0.35	-0.68	**-2.43**
3.	Ikot Abasi	-1.50	-1.39	0.19	-0.32	-0.17	-0.17	-1.05	0.16	1.43	**-2.82**
4.	Abak	-0.29	-1.09	0.20	-0.30	0.13	-0.88	-0.48	0.26	-0.33	**-2.78**
5.	Mkpat Enin	1.00	0.03	-1.60	-1.59	0.07	0.63	0.50	-1.21	1.49	**-0.68**
6.	Ikot Akpa Nkuk	0.34	-0.96	-0.43	-1.06	0.39	0.85	0.45	0.03	-0.56	**-0.95**
7.	Ikot Ekpene	-1.11	-0.42	-0.23	-1.56	-0.58	0.70	-0.33	-0.33	-0.36	**-4.22**
8.	Oron	-0.14	-0.25	0.69	-1.36	0.63	-0.32	-1.95	0.06	-0.38	**-3.02**
9.	Utu Etim Ekpo	-0.24	1.15	1.45	-0.81	0.84	0.17	0.21	-0.26	-1.46	**1.05**
10.	Idu	-0.64	-0.48	0.94	0.44	-0.66	-0.45	0.40	-0.32	-0.18	**-0.95**
11.	Urua Inyang	1.06	1.00	0.52	-0.08	0.60	1.58	-1.39	2.37	1.68	**7.34**
12.	Okorotte	0.29	-1.71	3.16	0.46	0.26	1.01	1.47	1.76	0.16	**6.86**
13.	Ikot Edibon	0.38	-1.25	-2.42	0.29	1.15	0.11	0.46	2.48	-0.70	**0.5**
14.	Uquo	-0.01	-1.52	0.06	1.10	1.45	-0.09	0.29	-1.21	-0.64	**-0.57**
15.	Uyo	0.19	-1.07	0.52	-0.94	0.26	-2.36	-0.93	-0.79	-0.94	**-6.06**
16.	Oko Ita	-0.29	0.41	-1.51	2.21	0.26	0.02	0.36	0.58	-0.30	**1.74**
17.	Odot Ikpe	0.05	0.37	0.14	0.80	1.12	0.40	-1.52	-0.46	1.65	**2.55**
18.	Eyofin	-0.32	0.32	0.09	1.36	2.42	-0.18	-1.18	-1.03	0.67	**2.15**
19.	Odot	-2.20	1.19	0.66	-0.83	-0.16	0.23	2.07	-0.36	1.75	**2.35**
20.	Afaha Ikot Ebak	-0.96	0.68	-0.57	-0.76	1.18	-1.09	1.34	0.23	0.23	**0.28**
21.	Urue Offong	0.91	2.25	-0.23	-0.97	1.73	-1.25	1.30	0.54	-0.74	**3.54**
22.	Ikot Ibritam	0.83	0.09	-0.16	1.09	-0.69	-1.24	0.32	-1.58	1.34	**0.00**
23.	Nto Edino	0.79	1.02	0.12	-0.21	-0.65	1.70	0.36	-0.27	-0.61	**2.25**
24.	Eket	-1.43	0.60	-1.17	-0.69	-1.46	0.67	-1.34	0.58	-0.88	**-5.12**
25.	Abat	-1.36	0.69	-0.75	0.37	-1.17	-0.03	-0.44	0.19	0.51	**-1.99**
26.	Upenekang	1.60	0.21	0.59	-0.47	-0.93	0.29	0.17	-0.92	1.00	**1.54**
27.	Nung Udoe	-0.69	0.14	0.34	0.20	-0.70	0.96	-0.66	-0.59	-1.60	**-2.6**
28.	Afaha Offiong	2.20	0.51	0.04	-0.13	-0.37	0.89	-0.22	-1.08	-1.36	**0.48**
29.	Okopedi	-0.14	0.47	0.06	2.07	-0.51	1.05	-0.35	-0.82	-0.59	**1.24**
30.	Mbak Atai	-0.70	1.22	0.58	1.58	-0.98	-1.06	0.74	0.68	-0.98	**1.08**
31.	Enwang	1.63	0.32	0.29	0.15	-2.07	-2.40	-0.60	1.52	0.86	**-0.3**
	TOTAL										**-0.05**

F1 – Environmental Sanitation/Housing Needs Factor, F2 – Asset Factor, F3 – Wellbeing Factor, F4 – Credit/Food Security Factor, F5 – Electronic Devices Factor, F6 – Household Facilities Factor, F7 – Basic Needs Factor, F8 – Education/Energy Factor, F9 – Building Quality Factor

Using NBS (2020) approach, poverty classification is shown in Table 6. On the basis of this classification table and as shown in Table 6, the study revealed a composite score of -0.05 in the dimension of distribution of factors of poverty in the urban areas of Akwa Ibom State thus indicating that the State is within the moderately poor categorization. From the classification it could be established that Urua Inyang , Okoroette and Urue Offong are in the extremely poor category while Afaha Ikot Ebak, Ikot Ibritam, Nto Edino, Upenekang, Afaha Offiong, Okopedi, Utu Etim Ekpo, Ikot Edibon, Oko Ita, Odot Ikpe, Eyofin and Mbak Atai are in the very poor categorization. The study further showed that the moderately poor areas are Ibiaku Ntok Okpo, Etinan, Ikot Abasi, Abak, Mkpat Enin, Ikot Akpa Nkuk, Idu, Uquo, Onna, Nung Udoe, Etinan, Abat and Enwang while the poor urban areas are Eket, Uyo, Ikot Ekpene and Oron. This result is as expected as the poor urban areas are actually the most urbanized and developed urban centres in the state.

Table 6: Poverty classification

Scores	Number of urban areas	Status
3.00-8.00	3	Extremely poor areas
0.00-2.99	11	Very poor areas
(-0.00) - (-2.99)	13	Moderately poor areas
(-8.00) - (-3.00)	4	Poor areas

Variation in Environmental Sanitation/Housing Needs: In the study area Factor 1 which has to do with environmental sanitation/housing needs had 15 out of 31 urban areas with positive score; indicating an average performance. Table 7 shows that out of the 15 urban areas 5 stood out as performing poorly on the dimension, such as Mkpat Enin, Urua Inyang, Upenekang, Afaha Offiong and Enwang. There were fewer funds to cater for the accommodation of the people and provision of adequate housing to meet the needs of the people in the area. This implies that majority of the households in the study area have little access to better housing vis-à-vis good environmental sanitation. Table 7 shows the performances of all the urban centers with positive scores on environmental sanitation/housing needs and on basis of poverty classification; these areas belong to very poor urban areas.

Table 7: Factor 1- Environmental sanitation/housing needs factor

S/N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Urban Areas	Ibiaku Ntok Okpo	Etinan	Mkpat Enin	Ikot Akpa Nkuk	Urua Inyang	Okorotte	Ikot Edibon	Uyo	Odot Ikpe	Urue Offong	Ikot Ibritam	Nto Edino	Upenekang	Afaha Offiong	Enwang
Scores	0.5	0.26	1	0.34	1.06	0.29	0.38	0.19	0.05	0.9	0.83	0.79	1.6	2.2	1.63

Variation in Asset Factor: The result of the study shows that in Table 8, 19 urban areas indicated positive performance on the scores and this implies that majority of the persons have little access to business activities and reduced assets. Also, the performances of 6 urban areas of Urue Offong, Mkpat Enin, Urua Inyang, Odot, Nto Edino and Mbak Atai (1.00 and above) become more challenging to efficient and effective establishment of strong business consciousness and enhanced economic space in the study area. The observed variation in the business and asset accumulations could be due to unemployment, inability to tap through the natural resources that are existent in the areas, poor infrastructure provision, weak business and financial structure of the people and inaccessibility to income generating ventures. Let it be noted that lack of asset building capacity among the urban dwellers may result in the denial of opportunity by the households to insulate themselves against shock, for which asset could be mortgaged for loan and converted to cash where immediate finance would not be available.

Table 8: Factor 2 – Asset factor

S/N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Urban Areas	Mkpat enin	Utu Etim Ekpo	Urua Inyang	Oko Ita	Odot Ikpe	Eyofin	Odot	Afaha Ikot Ebak	Urue Offong	Ikot Ibritam	Nto Edino	Eket	Abat	Upenekang	Nung Udoe	Afaha Offiong	Okopedi	Mbak Atai	Enwang
Scores	0.03	1.15	1	0.41	0.37	0.32	1.19	0.68	2.25	0.09	1.02	0.6	0.69	0.21	0.14	0.51	0.47	1.22	0.32

Variation in Wellbeing: On factor 3 which has to do with occupation and wellbeing of the people, a total of 19 out of 31 urban areas studied had positive scores indicating a negative performance. This distribution is shown in Table 9. Out of the 19 urban areas 2 stood out as performing below expectation. These are Utu Etim Ekpo and Okorotte. Others performed better-off than them. Higher positive scores imply worsening poverty levels.

Table 9: Factor 3 –Wellbeing factor

S/N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Urban Areas	Ikot Abasi	Abak	Oron	Utu Etim Ekpo	Idu	Uruainyang	Okorotte	Uquo	Uyo	Odot Ikpe	Eyofin	Odot	Nto Edino	Upenekang	Nung Udoe	Afaha offiong	Okopedi	Mbak Atai	Enwang
Scores	0.19	0.2	0.69	1.45	0.94	0.52	3.16	0.06	0.52	0.14	0.09	0.66	0.12	0.59	0.34	0.04	0.06	0.58	0.29

Variation in Credit/Food Security: Table 10 explains the credit and food security factor of the analysis. Out of 31 urban areas 14 showed some negative performance while 7 urban areas of Uquo, Oko Ita, Eyofin, Ikot Ibritam, Nung Udoe, Mbak Atai and Okopedi had scores above 1.0 on this factor. The area could be said to be experiencing very poor status of poverty on the basis of credit and food security. Access to credit facility is considered a major strategy to generating growth, accelerating human development and reducing the scorch of poverty among the people, (Eboreime, 2008). Increased income would generate increased savings, investment and capital formation thus increased productivity. It could be noticed that with the influx of people to the urban centres by migrants from the rural areas the tendency of food prices to go high became very imminent. Apart from that the total dependence on purchased food contributed greatly to the insufficiency of foodstuff in the areas. This could be traceable to the fact that potential agriculturists/farmers would migrate to the urban areas for 'white collar' jobs which were not available thus neglecting to cultivate the land for food. As mentioned earlier, without strong business enterprise base there would be no avenue to generate credit to fund any enterprise, thus lack of food sufficiency and a challenge to food security.

Table 10: Factor 4 – Credit/food security factor

S/N	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Urban Areas	Ibiaku Ntok Okpo	Idu	Okorotte	Ikot Edibon	Uquo	Oko Ita	Odot Ikpe	Eyofin	Ikot Ibritam	Abat	Nung Udoe	Mbak Atai	Okopedi	Enwang
Scores	0.2	0.44	0.46	0.29	1.1	2.21	0.8	1.36	1.09	0.37	2.07	1.58	2.07	0.15

Variation in Electronic Devices: Table 11 shows the variation in electronic devices as a factor with 14 urban areas performing positively out of the 31 urban areas. Among them are Ikot Edibon, Uquo, Odot Ikpe, Eyofin, Afaha Ikot Ebak and Urue Offong. The use of electronic devices is an index to determine the improved livability of a household. A significant proportion indicated that a lot of the persons do not have access to these devices thus impinging on their wellbeing. Much need to be done to cause household income to increase through gainful employment and access to funds for investment thus boosting the economic lives of the various households in the area.

Table 11: Factor 5 – Electronic devices factor

S/N	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Urban Areas	Abak	Mkpat Enin	Okorotte	Ikot Edibon	Uquo	Oron	Odot Ikpe	Eyofin	Utu Etim Ekpo	Urua Inyang	Uyo	Ikot Akpa Nkuk	Afaha Ikot Ebak	Urue Offon
Scores	0.13	0.07	0.26	1.15	1.45	0.63	1.12	2.42	0.84	0.6	0.26	0.39	1.18	1.73

Variation on Household Facilities: The availability and affordability of household facilities are positive indicators in the development of an area. Table 12 shows that out of the 31 urban areas in the State 17 areas had positive scores on this dimension, which is above average of the total variation in the area. Much needed to be done to building on the accumulation of household facilities in order to insulate the people from economic and social shocks since these represent household's inventory of wealth and thus affect the income flow of families. It is therefore important to also note that certain households may be poor in terms of immediate cash flow but are wealthy in terms of their property/facilities as present in the houses.

Table 12: Factor 6 – Household facilities factor

S/N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Urban Areas	Ibiaku Ntok Okpo	Mkpat Enin	Ikot Akpa Nkuk	Ikot Ekpene	Utu Etim Ekpo	Urua Inyang	Okorotte	Ikot Edibon	Oko Ita	Odot Ikpe	Odot	Nto Edino	Eket	Upenekang	Nung Udoe	Afaha Offiong	Okopedi
Scores	0.61	0.63	0.85	0.7	0.17	1.58	1.01	0.11	0.02	0.4	0.23	1.7	0.67	0.29	0.96	0.89	1.05

Variation in Basic Needs: On this aspect, 5 urban areas of Ibiaku Ntok Okpo, Okorotte, Odot, Urue Offong and Afaha Ikot Ebak had positive scores (above 1.0) while 12 have scores between 0.13 and 0.50 on this factor. Generally 17 urban areas out of 31areas have positive scores indicating above average performances on this factor. This is shown in Table 13. These basic needs include things such as food, clothing, shelter, education, health, work and mobility.

Table 13: Factor 7 – Basic needs factor

S/N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Urban Areas	Ibiaku Ntok Okpo	Mkpat enin	Ikot Akpa Nkuk	Etinan	Utu Etim Ekpo	Idu	Okorotte	Ikot Edibon	Oko Ita	Uquo	Odot	Nto Edino	Afaha Ikot Ebak	Urue Offong	Ikot Ibritam	Upenekang	Mbak Atai
Scores	1.85	0.5	0.45	0.13	0.21	0.4	1.47	0.46	0.36	0.29	2.07	0.36	1.34	1.3	0.32	0.17	0.74

Variation in Education/Energy: Table 14 had 15 urban areas out of 31 with 4 areas of Urua Inyang, Okorotte, Ikot Edibon and Enwang having positive scores above 1.0 and the rest having scores between 0.03 and 0.68.

Table 14: Factor 8 – Education/energy factor

S/N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Urban Areas	Etinan	Ikot Abasi	Ikot Akpa Nkuk	Abak	Oron	Urua Inyang	Okorotte	Ikot Edibon	Oko Ita	Afaha Ikot Ebak	Urue Offong	Mbak Atai	Eket	Abat	Enwang
Scores	0.35	0.16	0.03	0.26	0.06	2.37	1.76	2.48	0.58	0.23	0.54	0.68	0.58	0.19	1.52

Variation in Building Quality: Factor 9 established the building quality factor with 13 out of 31 urban areas studied having 7 areas of Ikot Abasi, Mkpat Enin, Odot, Ikot Ibritam, Odot Ikpe, Urua Inyang and Upenekang with positive scores above 1.0; and 6 urban areas between the range of 0.16 and 0.86 scores. This is shown in Table 15.

Table 15: Factor 9 – Building quality factor

S/N	1	2	3	4	5	6	7	8	9	10	11	12	13
Urban Areas	Ibiaku Ntok Okpo	Ikot Abasi	Okorotte	Mkpat Enin	Odot	Ikot Ibritam	Odot Ikpe	Eyofin	Abat	Urua Inyang	Upenekang	Enwang	Afaha Ikot Ebak
Scores	0.53	1.43	0.16	1.49	1.75	1.34	1.65	0.67	0.51	1.68	1	0.86	0.23

Mitigating the menace of poverty in any society especially in developing societies requires an in-depth investigation into the multi-dimensional nature of poverty. One dimension of poverty is its geographical spread in terms of spatial pattern associated with urban structure. The research work sought to appreciate the spatial pattern of poverty in the urban areas of Akwa Ibom State, and the findings revealed that poverty is severe in most of the urban areas in Akwa Ibom State. From the result, lack of improved access infrastructure poses grave danger to the urban areas. Apart from Uyo, Ikot Ekpene and Eket other urban areas suffer the problem of adequate and quality infrastructure such as paved roads, frequent public electricity supply, public water supply and health care services. World Bank adopted the acceptable maximum distance of five kilometers people should walk to a paved road where socio economic activities such as market, hospitals, schools, water supply are located. But it was observed that some roads in most urban areas were in a deplorable state while some were impassable. This finding corroborates earlier reports from Atser (2012) that local roads are the most under-developed category of roads in the country.

The result of this study has shown the relevance of education on poverty reduction in the area. It showed that access to education has helped in the increase in the stock of human capital and labor productivity thus increase in wages, which have helped in the reduction of poverty in the area. Alfa and Adeniji (2003), stated that with adequate education poverty will be reduced, and eventually eradicated, paving

way for sustainable national development as a result of improved quality of personal lives and social integration. In the light of this, such quality and type of education that can address the issue of poverty among the urban dwellers must be that which will equip them to address areas that keep perpetuating poverty. Some parents believe that most children who graduate from schools do not do better than those who go directly to be involved in artisan trade such as carpentry and upholstery making, weaving and fashion design, motor mechanic work, and such light/service industrial activities. To a greater extent they believe that the present education acquired would not solve the problem of poverty. This is so, since the present education offered by the government of the day would not resolve the poverty status and translate one into sustained means of livelihood so as to create significant difference in the level of income to the households. This certainly has great implications in the design of poverty policies by relevant agencies of government and stakeholders.

Conclusion and Recommendations

The research analyzed the spatial pattern of poverty in the urban areas of Akwa Ibom State. It revealed that there are basically four (4) clusters of poverty profile in the urban areas of the State based on the poverty indicators as established in the research. The study showed that there is general poverty in the urban areas of the State; some are deep in poverty than others. Also, there is a large scale inequality in the spatial distribution of facilities and services in the study area vis-à-vis the distribution of economic growth in Akwa Ibom State. Therefore, if the situation is allowed to persist, it has a tendency to further impoverish most urban households in the study area of the State. From the analysis of findings it is obvious that poverty exists in the urban areas of Akwa Ibom State and manifests itself in different patterns which range from environmental sanitation, assets, wellbeing, food security, to building quality, education and basic needs. Therefore, any attempt to improving these factors will be a step in the right direction in alleviating poverty in Akwa Ibom State and Nigeria as a whole. Planning measures should rather be directed towards promoting economic growth and stability, which are necessary conditions for poverty reduction, especially when they translate into more and better jobs for the poor. A large number of more satisfactory employment opportunities are a prerequisite for the success of poor households' efforts to attain financial self-reliance. It is held that as the national product increases, given a fair and more equitable distribution of the national income, the areas of depressions and poverty can be reduced. Adequate level of basic amenities such as water, education, health and electricity should, however, be provided and sustained. In conclusion, the study has generated a compendium of baseline data on urban poverty in Akwa Ibom State that can be very useful for the design of poverty policies, and for project intervention by development agencies at both local and international levels. By highlighting those areas that are better-off and worse-off, the study has also indirectly revealed the extent of the commitment of Akwa Ibom State Government towards actualizing the objectives of the Sustainable Development Goals (SDGs). Besides, Government Poverty Alleviation Programmes should be restructured and redesigned to centre on the 'basic needs' approach. This approach emphasizes the importance of separating generalized increase in income from the more significant attainment of the requirements for a permanent reduction of poverty through the provision of health services, education, housing, sanitation, water supply, energy and other wellbeing indicators. The rationale for this approach is that the direct provision of such goods and services is likely to relieve absolute poverty more immediately than alternative strategies, since growth strategies usually fail to benefit the intended target and the productivity and income of the poor depend in the first place on the direct provision of basic needs.

References

Abiola, A. G. and Olaopa, O. R. (2008). Economic development and democratic sustenance in Nigeria, pp 25-34. In: E. O. Ojo (Editor). Challenges of sustainable democracy in Nigeria. John Archers Publishers Limited, Ibadan, 389p.

Addae-Korankye, A. (2014). Causes of poverty in Africa: A review of literature. *American International Journal of Social Science.* 3 (7):147-153.

Akwa Ibom State (1989). *Physical background, soil, land use and ecological problems*. A technical report of the task force on soils and ecological problem. A technical report of the task force on soils and land use survey of Akwa Ibom State. Government Printer. Uyo, 154p.

Alkire, S., and Santos, M. E. (2014). Measuring acute poverty in the developing world: robustness and scope of the multidimensional poverty index. *World Development*, *59*:251–274.

Alkire, S., Jindra, C., Robles, G. and Vaz Ana (2016). *Multidimensional poverty index- summer 2016: Brief methodological note and results*. Oxford Poverty and Human Development Initiative. Oxford, 23p.

Atser, J. (2012). *Spatial pattern of social infrastructure in Nigeria.* Lambert Academic Publishing (LAP) AV, Akademikerverlag GmbH & Co. KG,156 p.

Coudouel, A., Hentschel, J. S. and Wodon, Q. T. (2002). *Poverty measurement and analysis in the PRSP sourcebook.* Washington D.C.: The World Bank. Link: http://poverty2.forumone.com/files/5467_chap1.pdf. (Retrieved on 29th October, 2018).

Davis, B. (2003). *Choosing a method for poverty mapping*. Rome: Food and Agriculture Organizations of the United Nations. Link: http://www.fao.org/docrep/005/Y4597E/Y4597E00.HTM. (Retrieved on 15th March, 2010).

de Pérez, R. G. (2007). *Using GIS to define grades of poverty*. Grupo ESRI de Venezuela. http://www.proceedings.esri.com/library/userconf/proc05/papers/pap1828.pdf. (Retrieved on 15th March, 2010).

Ekpo, A. H. and Uwatt, B. U (2005). *Akwa Ibom State of Nigeria: poverty profile and economic transformation.* Foundation for Economic Research and Training, Uyo.129p

Elhadary, Y. A. (2012). Political economy and urban poverty in the developing countries: lessons learned from Sudan and Malaysia. *Journal of Geography and Geology*, 4(1):212-223.

Esin, J. O. (2013). *Spatial Analysis of Rural Poverty in Akwa Ibom State, Nigeria.* PhD Thesis, University of Uyo, Nigeria, p116.

Glasmeier, A.; Martin, R. Tyler, P and Dorling, D. (2008). Editorial: Poverty and place in the UK and USA. *Cambridge Journal of Regions, Economy and Society,* (1):1-16.

GCIP (Global Consumption and Income Project). (2019). *World data*. www.un.org. (Retrieved on 12th March, 2021)

Henninger, N. H. and Snel, M. (2002). *Where are the poor? Experiences with the development and use of poverty maps.* Washington D.C. and Arendal, Norway: World Resources Institute and United Nations Environment Programme GRID-Arendal. Link: http://www.povertymap.net/publications/whereareth epoor/. (Retrieved on 19th May, 2009).

Hyman, G., Larrea, C. and Farrow, A. (2005). Methods, results and policy implications of poverty and food security mapping assessments. *Food Policy,* 30: 453-460.

Iheonu, C. O. and Urama, N. E. (2019). *Addressing poverty challenges in Nigeria*. AfriHeritage Policy Brief. No.21, July 2019, 5p.

Kisiała, W. and Racka, I. (2021). Spatial and statistical analysis of urban poverty for sustainable city development. *Sustainability*, 13 (858):1-18.

Lain, J. and Vishwanath, T. (2021). *Tackling poverty in multiple dimensions: a proving ground in Nigeria?* World Bank. https://blogs.worldbank.org/opendata/tackling.poverty... (Retrieved on 12th March, 2021).

Milbourne, P. (2004). The local geographies of poverty: A rural case-study. *Geoforum*, 35: 559-575.

NBS (National Bureau of Statistics). (2020). *Demographics of Nigeria – statistics & facts*. https://www.statista.com/topics/6477/demographics... (Retrieved on 12 March, 2021).

Nwaobi, G. C. (2003). *Solving the poverty crisis in Nigeria: an applied general equilibrium approach.* Quantitative Economic Research Bureau. Gwagwalada, Abuja. 34p.

Ofem, B. and Inyangmme, U. A. (2013). Analysis of urban poverty and its implications on development in Uyo Urban, Akwa Ibom State. *Nigerian Journal of Agriculture, Food and Environment*, 9(4):49-56.

Ogolo, M. B. (2012). Proposal for International funding: Students' guide to writing research and project proposals. *Journal of Scientific and Industrial Studies*, 8(3):85-91

Olayemi, A. O. (2013). Analysis of poverty level among urban households in Inirewole Local Government Area of Osun State. *Global Journal of Arts Humanities and Social Sciences*, 1(1):13-19.

Orokpo, O. F., Haruna P. O., Asmau M. A. and Mutong, S. M. (2018). Nigeria's raising poverty profile amidst poverty alleviation programmes: interrogating the paradox. *International Journal of Innovative Development and Policy Studies,* 6(2):109-116.

Tharenou, P., Donohue, R. and Cooper, B. (2007). *Management research methods*. Cambridge University Press, Cambridge. 338p.

Udofia, E.P. (2011). *Applied statistics with multivariate method*. Immaculate Publications Ltd, Enugu, 294p.

UNDP (United Nations Development Program). (2004). Somalia United Nations Development Program Somalia. *Key indicators of poverty in Somalia*. Discussion Paper, April 2004, Poverty Reduction and Economic Recovery, 32p.

Vaughan, L., Clark, D. C., Sahbaz, O. and Haklay, M. (2005). Space and exclusion: does urban morphology play a part in social deprivation? *Area,* 37: 402-412.

Wang, Y and Wang, B.(2016). Multidimensional poverty measureand analysis: a case study from Hechi City, China. *SpringerPlus,* 5:642.

World Bank (2007): *Poverty at a glance*. World Bank Issue Brief/Poverty. Washington D. C., 136p.

World Bank (2010). *World Bank Updates: poverty estimates for developing world in a divided world.* Pal grave Macmillan. http://econ.worldbank.org. (Retrieved on 12 July 2015).

World Bank (2018). *Poverty and shared prosperity 2018*, The World Bank, Washington, DC, 98p.

World Data Lab. (2019). *The percentage of Nigerians living in extreme poverty could increase by 2030*. Retrieved from World Poverty Clock: www.worldpoverty.io/blog/index.php. (Retrieved on 12 March, 2021).

Yusuf, R. O. (2008): Participatory appraisal of poverty in the rural settlements of Kaduna State, pp153-174. In: Igbozurike, U.M; Awuze, U.A and Onyenechere, E.C. (Editors.). *Rural Poverty in Nigeria.* Cape Publishers Int'l Ltd, Abuja, 180p.

CALCIUM CARBIDE WASTE (CCW) USED AS A PARTIAL REPLACEMENT OF CEMENT IN CONCRETE

ARDO Yusuf[1], HASSAN Murtala Mohammed[2], SANI Mohammed Abdullahi[2], BULUS Micheal Nyampa[3]

[1]Department of Building, Modibbo Adama University, Yola.
[2]Department of Civil Engineering, Modibbo Adama University, Yola.
[3]Department of Civil Engineering, Adamawa State Polytechnic, Yola.
Correspondence email:yusufardo@gmail.com Phone:07039662646

ABSTRACT
Urban Nigeria is a rapidly growing construction site. The cost of construction is high partly due to the high cost of cement. Any effort at introducing cheaper alternatives or partial replacement of cement in concrete will reduce cost. An alternative is found in Calcium Carbide Waste (CCW). CCW is a by-product of oxyacetylene gas welding, it is a waste product that is often dumped in landfills and it poses environmental challenges to the underground water and ambient air. If converted to a construction material, it will both reduce cost of construction and environmental pollution. CCW consists of 65.05% calcium oxide and traces of Alumina, magnesium oxide, silicates and sulphide. This study investigated the potential of using CCW used as partial replacement of Cement in concrete production, on a concrete grade of M15 was used to produce concrete by replacing cement at 5%, 10%, 15%, and 20% respectively and the concrete were cured for 7, 14 and 28days respectively. The Calcium Carbide Waste Concrete (CCWC) tested for Compressive strength indicates a general trend of decreasing strength with increasing percentage of cement replacement. However, all the results obtained were above the minimum characteristic strength of 15N/mm^{2}for M15 except for the concrete produced with 20% replacement and cured for 7days which has a characteristic strength of 14.6 N/mm^{2}which is slightly below. The result also showed decrease in setting time with increase in percentage cement replacement and the degree of workability measured from slump test of the CCWC indicates a low workability for all the tested concrete.
Keywords: *Calcium Carbide Waste, Cement, Concrete Compressive Strength, Setting Time.*

Introduction

The high cost of building material especially cement has greatly affected the housing sector in Nigeria. Cement is not only costly, but it requires enormous heat for its manufacture and it contributes immensely to the pollution of the environment by producing greenhouse gases which has led to a search for alterative to reduce the emission of CO_2. In addition to cost, high energy in construction activities serve as means or mechanism for the realization of human settlement. However, a problem associated with construction activities is that it is responsible for approximately 40% natural resources consumption of the non-decaying waste materials will remain in the environment for hundreds, perhaps thousands of years. The non-decaying waste materials had caused a waste disposal crisis, thereby contributing to the environment problem. The problem of waste accumulation exists worldwide, specifically in the densely populated areas. Waste in the construction industry and the use of rejected materials is a subject of world research (Atkinson and Sakai, 1993).

Calcium Carbide Waste (CCW) is a by-product of the flammable acetylene gas production. It is called lime hydrate or carbide lime sludge. Calcium carbide is a chemical compound containing calcium & carbide, with a chemical formula of CaC_2. Pure calcium carbide is colorless, but most of the material is produced industrially. The reaction of calcium carbide with water produces this all-important gas that is used in oxygen – acetylene welding, among other uses. The CCW from the production of acetylene gas are normally disposed of by land filling which may create further problem, like, the leaching of harmful compound and Alkali to ground water. Inhalations and disposed CCW in the environment would affect both human being, plants & animals and it is very hazardous substance (Colin, 2006).

The construction industry has experienced major innovations in concrete production methods alternative to conventional concrete (Franco *et al.*, 2021). According to Naik (2008) concrete production innovations encourage sustainability, reduce project delivery time, improve on-site waste management, and reduce the total construction cost. According to Singh (2008), sustainability has become a worldwide goal. Green or sustainable buildings use key resources like energy, water, minerals and land

much more efficiently than those merely built according to codes. Fapohunda *et al.* (2017) stated that global warming triggered by the emission of greenhouse gases, such as carbon dioxide (CO2), into the atmosphere can be reduced by replacing gas-emitting materials. One of these substitute materials is Calcium Carbide Waste which has been established to have chemical compositions similar to that of Ordinary Portland Cement. According to Ndububa and Omeiza, (2000) cement replacement materials (CRM) are materials that can be used for substituting cement in the production of concrete or other cementitious products. For a material to be used as a cement replacement material, it must possess pozzolanic properties. In the recent wake of the need to produce sustainable concrete, conserve the environment, reduce greenhouse effects in construction, the use of industrial and agricultural wastes has found as cement replacement materials for example Fly ash, Ground granulated blast-furnace slag (GGBS), Silica fume, Limestone, Rice husk ash, Palm oil fuel ash, Sugarcane bagasse ash, fly ash, GGBS, silica fume, and limestone fines are industrial wastes while rice husk ash, palm oil fuel ash and sugarcane bagasse ash are agriculture wastes. A variety of byproducts from industry may be utilized in multicomponent binder materials utilized in multicomponent binder materials for a variety of purposes (Smirnova., 2019). Diverse studies have been carried out on building concrete using supplemental components to decrease the price and scarcity of standard materials (Vigneshpandian *et al.,* 2017, Jawad *et al.,* 2022). Concrete is the very often utilized man-made construction resource in the building business, and hydraulic cement is a vital component of this material. Alternative approaches include using organic gas as a gasoline substitute for coal for calcination, using chemicals to absorb carbon dioxide efficient grinding process for clinker and incorporating sustainable cement manufacturing Implementing cementitious materials, on the other hand, may be a practical strategy for significantly reducing greenhouse gas emissions. Manufacturing wastes, such as Ground Granulated Blast Furnace Slag **(**GGBS), silica fume, metakaolin and fly ash, are used as a substitute for OPC and can potentially cut greenhouse gas emissions by a significant amount. Table 1.1 shows the chemical composition of different cementitious materials (GGBS, silica fume, metakaolin and fly ash) as in past literature on the topic. According to ASTM pozzolanic materials may be formed by the accumulation of chemicals, such as silica, calcium, alumina, magnesia and iron, to a concentration of more than 70%. Silica, calcium, alumina, magnesia and iron are among the elements that have accumulated in GGBS at a concentration greater than 70%. As a result, GGBS silica fume, metakaolin and fly ash have the potential to be used (pozzolanic material) that may be utilized as an OPC substitute in concrete.

Table 1 Chemical Composition of Different Cementitious Material

Chemicals	Fly Ash	Silica Fume	Metakaolin	GGFS
SiO_2	54.22	34.32	54	37.5
Al_2O_3	31.18	15.57	43	6.4
Fe_2O_3	2.63	0.58	1.2	0.51
CaO	0.47	6.89	0.4	8.6
MgO_2	1.24	37.52	0.4	34.6
Na_2O	0.49	0.31	0.3	0.38
K_2O	1.3	0.66	0.3	-
References	Karimipour *et al* 2021	Zhang *et al* 2021	Nazrpour *et al* 2020	Liu *et al* 2020

Source: Jawad *et al.,* 2022

According to (Thomas 2007) Pulverised Fuel Ash (PFA) can be used to replace cement at different percentage replacement levels leading to varying strengths and other properties. High percentage replacement (beyond 30%) is usually used in mass construction such as dams and foundations, to control temperature rise.

Materials and Method

Cement: Ordinary Portland cement (OPC) was used composition and properties of which conform to the Nigerian standard organization defined standard of cement for concrete production.

Calcium Carbide Waste: The CCW was obtain from a local panel beating workshop waste dumps in Sengere, Girei Adamawa State Nigeria, the CCW material was sundried and sieved through a 75 µm

sieve. Oxides composition analysis of the CCW was conducted using optical emission spectroscopy (OES) analytical method.

Table 2 Oxide Composition of CCW and OPC

Materials	Chemical Oxide (%)								
	SiO_2	Al_2O_3	CaO	Fe_2O_3	MgO	Na_2O	K_2O	ZnO	LOi
CCW	6.69	2.30	89.76	0.30	-	0.02	0.09	-	16.62
OPC	22.00	3.11	62.00	4.65	2.06	-	0.40	0.86	-

Aggregate: The research work is restricted to sand collected from the river. The sand was collected to ensure that there was no allowance for deleterious materials contained in the sand.

In this research, granite of 20mm maximum size was used. Proper inspection was carried out to ensure that it is free from deleterious materials. Granite was gotten from Triacta quarry in mayo belwa Adamawa state.

Water: Water is the cheapest and most important ingredient of concrete production (mix) it is water that initiate the reaction between the pozzolan, cement and the aggregates. It helps in the hydration of the mix. For this research, the water used was a Pipe borne water and free from contaminants.

Method: Fine and coarse aggregates, cement, calcium carbide waste (CCW), and water were combined to form concrete and Calcium Carbide Waste Concrete by replacing cement with CCW at 0%, 5%, 10%, 15% and 20% respectively using a concrete grade of M15. In this research CCW was used as partial replacement for cement. All the cubes were cast with the same volume proportions and after placement in mould; they are left to set for 24 hours, and then cured for 7 days, 14days and 28days for compressive strength.

Result and Discussion

Consistency and Setting Time of the Combination of Cement and Calcium Carbide Waste

Consistency of cement and setting time were determined on both ordinary Portland cement and the mixture of OPC and CCW to establish the required amount of water needed to be added to the binder material for the development of strength and workability of the concrete. Table 3 presents the values of the consistencies of OPC and the mixture of OPC with CCW at 5, 10, 15, and 20%, respectively. Therefore, from the result obtained, it was observed that the consistency of OPC alone and the mixture of OPC and CCW are within the normal range of standard consistency of 26–38%. This implies that the mixture of cement and CCW at certain proportions can produce a concrete of strength similar to that produced with 100% cement. Also, from the results, it was noticed that the setting time of the combination of cement and CCW decreases with an increase in percentage CCW. This may be attributed to the addition of more calcium oxide, CaO, from calcium carbide waste, which is known to have an accelerated effect on the setting time of cement. Therefore, as the percentage of CCW increases in the mixture, the concentration of CaO also increases, thereby leading to a faster setting time.

Table 3 Consistency and Setting Time of OPC and Mixture of OPC and CCW

S/N	1	2	3	4	5
CCW (%)	0	5	10	15	20
Weight of OPC + CCW (g)	300+0 = 300	285+15 = 300	270+30 = 300	255+45 = 300	240+60 = 300
Weight of Water (g)	99	99	102	102	105
Consistency (%)	33	34	34	35	36
Initial Setting Time (min)	92	85	76	60	57
Final Setting Time (min)	250	227	220	214	206

Workability

Table 4 and Figure 1 present the results and plot of the slump test. From the result, it was observed that the slump values for the mixtures with 0%, 5%, 10%, and 15% CCW fall within the range of 42 mm to 51 mm, indicating a moderate workability of the mixtures, and the slump value for the mixture with 20% CCW is higher at 59 mm, indicating a higher workability or flowability of the mixture. Based on the slump values alone, it appears that the workability of the mixtures is relatively consistent for CCW percentages ranging from 0% to 15%. However, the mixture with 20% CCW exhibits a higher slump value, suggesting a more fluid consistency. Considering the compacting factor, which ranges between 0.7 and 0.85, it provides an indication of the overall workability and cohesion of the mixtures. This

result is in agreement with the earlier result of consistency, especially at 20% CCW, where a higher consistency value indicates a higher water requirement.

Table 4 Slump Result for OPC and Mixture of OPC and CCW

	CCW (%)				
	0	5	10	15	20
Compacting Factor	0.81	0.85	0.82	0.7	0.74
Slump Values(mm)	45	51	42	49	59

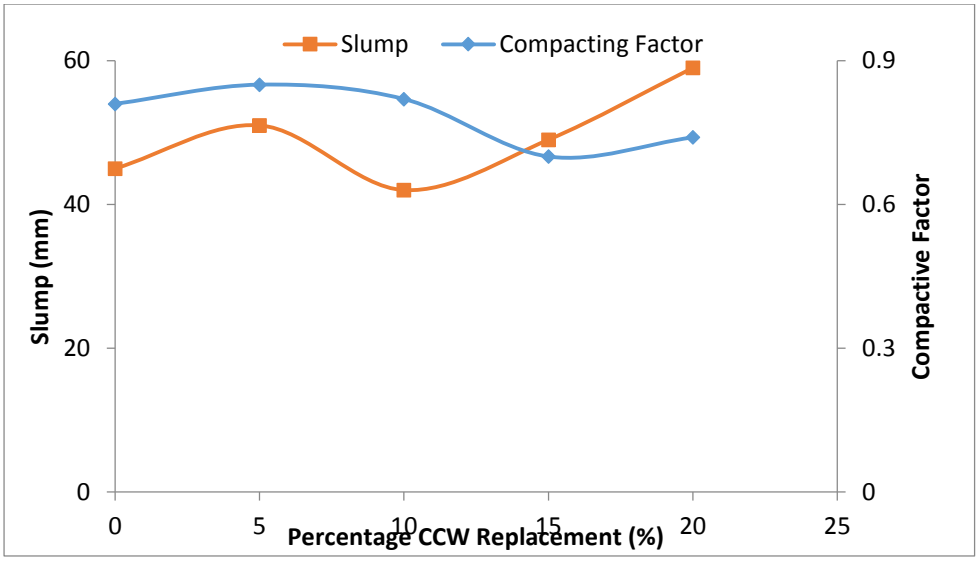


Fig. 1 Slum of CCWC

Compressive Strength

The compressive strength of Calcium Carbide Waste Concrete (CCWC) was investigated at 7, 14, and 28 days for 5%, 10%, 15%, and 20% replacement of cement with CCW, respectively. The result is presented in Table 5 and Figure 2. The result shows a decreasing compressive strength with increasing percentage of CCW for all the curing ages considered, with the highest compressive strength of calcium carbide waste concrete of 34.3 MPa recorded at 5% replacement under a curing age of 28 days. This phenomenon of decreasing strength with increasing percentage CCW replacement can be attributed to the pozzolanic activity of pozzolanic materials, which influences the development of strength. CCW exhibits some pozzolanic properties, which may not provide a pozzolanic reaction as strong as cement. As the CCW replacement percentage increases, the overall pozzolanic activity decreases, leading to a decrease in compressive strength. Furthermore, the Dilution Effect may play a role, as the inclusion of CCW in the mixture can dilute the amount of cementitious materials available for hydration. As the percentage of CCW increases, the overall cementitious content decreases, thereby reducing compressive strength.

Table 5 Result of Compressive Strength

	Curing Age (days)	Percentage replacement of CCW				
		0	5	10	15	20
Average Compressive Strength (MPa)	7	20.8	28.1	25.5	19.0	14.6
	14	26.1	32.1	28.5	23.4	19.5
	28	28.6	34.3	33.1	26.7	23.6

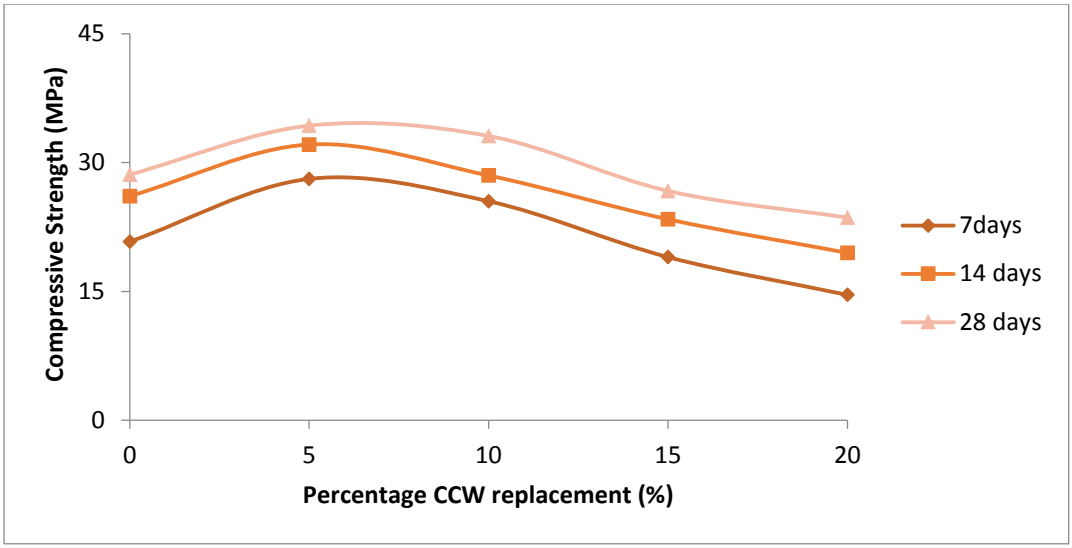


Fig. 2 Compressive Strength of CCWC

Conclusion

Based on the findings from this research work, it can be concluded that the use of Calcium Carbide Waste (CCW) in concrete and other civil engineering-related works will improve concrete quality, reduce the overall cost of construction, and solve environmental issues by reducing environmental pollution through the conversion of waste to construction material.
The addition of CCW to cement in concrete leads to an increase in water demand, which consequently results in increased workability and enhanced strength compared to the control sample with OPC. The strength of concrete at 28 days was found to be higher for all the concrete; the values were 34.3 MPa, 33.1 MPa, 26.7 MPa, and 23.6 MPa for 5%, 10%, 15%, and 20%, respectively. The result shows that adding CCW of 5%–10% will lead to the development of compressive strength higher than the control for all the curing ages considered, while adding 15%–20% results in compressive strength lower than the control. Overall, the compressive strength of CCWC is greater than the characteristic strength of M15 concrete grade, which is 15 MPa and can be used as plain concrete, especially for foundation work.

References

ASTM D6868; Standard Specification for Biodegradable Plastics Used as Coatings on Paper and Other Compostable Substrates. ASTM International: West Conshohocken, PA, USA, 2017.

Atkinson, C. J. and Sakai, E. (1993) Eco-labeling of Building Materials and Building Products. Building Research Establishment Information Paper. Vol.11, ser. 93.. London, UK.

Colin, M., (2006): The Fundamentals of Explosion Welding: 6th Edition. Shangh Publishers. Delhi. India

Fapohunda C, Akinbile B, & Shittu A. (2017). Structure and properties of mortar and concrete with rice husk ash as partial replacement of ordinary Portland cement – A review. International Journal of Sustainable Built Environment, 6(2), 675-692.

Franco M, Natasha M, Chipozya K T and Alice L (2021) Partial replacement of cement with rice husk ash in concrete production: an exploratory cost-benefit analysis for low-income communities. *Engineering Management in Production and Services* (13) https: //doi.org/127-141 10.2478/emj-2021-0026

Karimipour A and de Brito J (2021). Influence of Polypropylene Fibres and Silica Fume on the Mechanical and Fracture Properties of Ultra-High-Performance Geopolymer Concrete. Constr. Build. Mater. 283, 122753. [CrossRef]

Liu Y, Shi, C, Zhang Z and Li N, Shi D (2020) Mechanical and Fracture Properties of Ultra-High Performance Geopolymer Concrete: Effects of Steel Fiber and Silica Fume. Cem. Concr. Compos.112, 103665. [CrossRef]

Jawad A, Karolos J K , Ali M, Muhammad *et al* (2022) A Comprehensive Review on the Ground Granulated Blast Furnace Slag (GGBS) in Concrete Production in. Sustainability 14, 8783. https://doi.org/10.3390/su14148783

Naik, T R (2008). Sustainability of Concrete Construction. *Practice Periodical on Structural Design and Construction, 13*(2), 98-103.

Nazarpour H and Jamali M (2020). Mechanical and Freezing Cycles Properties of Geopolymer Concrete with Recycled Aggregate. Struct. Concr. 21, 1004–1012. [CrossRef]

Ndububa, and Omeiza (2016). Potential of calcium carbide waste as partial replacement of cement in concrete. Nigerian Journal of Tropical Engineering, ISSN: 1595-5397, 9(1-2), 1-9.

Smirnova, O. Compatibility of Shungisite Microfillers with Polycarboxylate Admixtures in Cement Compositions. ARPN J. Eng.Appl. Sci.

Smirnova O. (2019) Compatibility of Shungisite Microfillers with Polycarboxylate Admixtures in Cement Compositions. ARPN J. Eng. Appl. Sci., (14) 600–610
Singh, A. (2008). *Cost benefit analysis of green buildings.* New Delhi: Department of building Engineering & Management

Thomas M D A (2007). "Optimizing the Use of Fly Ash in Concrete," *Portl. Cem. Assoc.*, 24,

Vigneshpandian G V, Shruthi E A, Venkatasubramanian C, Muthu D (2017). Utilisation of Waste Marble Dust as Fine Aggregate in Concrete. IOP Conf. Ser. Earth Environ. Sci. 80, 012007. [CrossRef]

Zhang P, Wang K, Wang J, Guo J, Ling Y (2021) Macroscopic and Microscopic Analyses on Mechanical Performance of Metakaolin/Fly Ash Based Geopolymer Mortar. J. Clean. Prod. 294, 126193. [CrossRef]

APPLICATION OF THE METHODS OF INVESTING PENSION FUND IN REAL ESTATE FINANCING IN NIGERIA

Okeahialam, Chukwunyere Obinna[1] and Nwanekezie, Francis Okechukwu[2]
[1&2]Department of Estate Management, University of Uyo.
Email: chukwunyereookeahialamc@uniuyo.edu.ng
Phone No: +2348034957598.

ABSTRACT
This study aimed at determining which method of investing (investment instruments) is applied more than the other in the investing of pension fund in real estate in Nigeria. The two methods studied were Real Estate Investment Trusts (REITs) and investing in Direct Real Estate Property (DREP). Two objectives were set. Firstly, to determine the extent of the application of the methods of investing, secondly, to determine whether the difference in the extent of the application is significant. The study period was 2012 to 2021 and secondary data from PenCom was used. Data were analysed using percentages and Independent Samples T-test was used to test hypothesis. Findings showed that, the extent of the application of the methods of investing is poor with REIT and DREP asset classes having respective averages of 0.064% and 0.009%. Findings also showed that, the difference in the extent of the application of the two methods is not significant with a p-value of 0.514. For there to be improved real estate funding by pension fund, increased application of both instruments is strongly recommended.
Keywords: *Application, Methods of investing, Pension fund, Real estate financing.*

INTRODUCTION

Section 86h of the Pension Reform Act, 2014, stipulated that pension fund can be invested in real estate financing in Nigeria. It shall be invested by the pension fund managers as strictly stipulated by the investment regulations and guidelines issued by the National Pension Commission (PenCom) from time to time (section 85, subsection 2). Pension fund managers comprises of the Pension Fund Administrators (PFAs) and the Closed Pension Fund Administrators (CPFAs). At present, there are four approved methods of investing pension fund in real estate financing in Nigeria. They are, Mortgage Backed Securities (MBS), Real Estate Investment Trusts (REITs), investing in Direct Real Estate Property (DREP) and investing in Residential Mortgage Equity Payment (RMEP) in favour of contributors.

MBS and REITs are securitised investment instruments traded at the Stock Exchange. Investing in DREP entails the purchase of an already developed property or financing the development or construction of a property to generate income for the pension fund (section 1.3, Guidelines on Direct Real Estate Investments by Closed Pension Fund Administrators and Approved Existing Schemes, 2011). Investing in DREP is only permitted for pension fund of Approved Existing Schemes (AES) operating Defined Benefit Schemes (DBS). The pension fund of most AES operating DBS is managed by the CPFAs. Investing in RMEP in favour of pension contributors was introduced by Section 89 (2) of the Pension Reform Act, 2014. According to its provision, pension fund managers received permission subject to guidelines to be issued by PenCom to apply some percentage of pension fund assets in the Retirement Savings Account (RSA) of a contributor towards payment of equity contribution for residential mortgage. It is important to note that as at the period of this research (2012 – 2021) MBS is yet to be available as an investment instrument in Nigeria and therefore not enlisted at the Nigerian Stock Exchange (NSE) where it should be traded. Also, as at the period of this study, investing in RMEP has not taken effect and therefore lacked data for analysis.

The application of the methods of investing pension fund in real estate financing here implies how pension fund is applied in real estate investment financing in Nigeria through the approved investment instruments (methods). When broken down further, it implies the amount of pension fund invested in each of the real estate asset classes (methods) out of the available amount of pension fund for investment annually. The methods of investing (asset classes) in focus here are REIT and DREP because the other two (MBS and RMEP) are not yet effective in Nigeria and therefore lacked data for analysis.

This study aimed at determining which real estate asset class (method) is applied more than the other in the investing of pension fund in Nigeria with the view of making recommendations for improved application and funding because of the fundamental nature of real estate infrastructure in Nigeria which is in deficit at the moment. Two objectives were set to achieve this aim. The first is to examine the methods of investing pension fund in real estate financing in Nigeria to determine the extent of their application. When this objective is achieved it will also show differences in the extent of the application between the two methods of investing. The second objective is to determine through test of hypothesis whether the differences in the extent of the application of the two methods of investing is significant. This is expected to show the most accessible and viable method through empirical based evidence which should guide policy makers in the pension and real estate industry in identifying priorities towards improving the efficiency of the methods of investing with the view of strengthening the link between pension fund and real estate investment financing in Nigeria.

LITERATURE REVIEW

Around the world, investment of pension fund in real estate financing is applied through various methods. Farrelly and Moss (2014) categorized the methods into Public and Private methods of investing. It is also categorized into Listed and Unlisted methods (Moss and Farrelly, 2015). It can also be categorized into Direct and Indirect methods (Andonov *et al.,* 2015). Public method can synonymously be referred to as Listed method or Indirect method. Private method can synonymously be referred to as Unlisted method or Direct method. Public method entails all listed investment instruments at the stock exchange. They are securitized real estate investment instruments such as MBS and REITs. They are termed Indirect because pension fund invests through proxies. Private method entails direct real estate investment made by pension fund without going through proxies or intermediated money managers. Such investments are not listed at the stock exchange. An example is where pension fund engages directly in the construction or purchase of landed property for income generation.

The nature of the involvement of pension fund in financing real estate investments depends on the peculiarity of every country. The peculiarity indicates the need the country might have and where it would want pension fund to intervene in real estate financing. For instance, because of the need to provide an alternative source of housing finance to the low and middle income earners who were priced out of the formal mortgage finance market, the South African government introduced the use of pension fund as a residential mortgage finance instrument to the benefit of contributors (Afrane *et al.,* 2014). The peculiarity of a country would give an indication on the instruments through which pension fund can be invested in real estate. In Nigeria for instance, because of the need to secure pension fund assets, investment of savings from the Defined Contributory Scheme (DCS) in real estate is restricted to MBS and REIT (Adjekophori, 2014; Nubi and Adewunmi, 2011). The restriction to MBS and REIT is also aimed at developing and strengthening the MBS and REIT sector and the Nigerian stock market where they are traded. Incidentally, despite restricting pension savings from DCS to invest only in securitized real estate instruments, this aim is defeated with regards to MBS because at the moment no MBS is listed at the stock exchange in Nigeria where pension fund can make investment.

Arguably, none of the few known studies in Nigeria on pension fund and real estate financing has investigated the application of the methods of investing with regards to the amount of investment made in each of the instrument (asset class). Arguably, no known study in Nigeria has investigated which real estate asset class is applied more than the other in the investing of pension fund by determining the extent of their application and whether the difference in the extent of their application is significant.

Nubi and Adewunmi (2011) examined the two main instruments prescribed for the investment of pension fund in real estate (MBS and REITs), the problems involved in their use and factors influencing the level of their participation and performance. Their result showed that, pension fund managers are enthusiastic about investing in MBS and REITs but are limited in investing mainly because of risk. The authors did not focus on determining the extent of the application of MBS and REITs in the investing of pension fund which would have preceded by ascertaining the amount invested in the two of them (MBS and REITs). Their choice of different focus also gave rise to not determining the difference in the extent of the application of MBS and REITs and whether the difference in the extent of the

application is significant. It must be noted that, one of the shortcomings of the study conducted by Nubi and Adewunmi (2011) is that, after enumerating and discussing the challenges of MBS in Nigeria they erroneously failed to assert that no MBS is enlisted at the Nigerian Stock Exchange.

Oni (2013) determined the joint and individual impacts of the variables of money market indicators on pension fund contributions from which finance could be made available for real estate development in Nigeria. The author used Pearson's product moment correlation model to analyse secondary data from Central Bank of Nigeria (CBN) and PenCom. Findings showed that, all the money market indicators have high and positively correlated relationships amongst each other and that they reacted positively towards invigorating the participation of pension fund in real estate investment financing. Again, the author did not focus on determining the extent of the application of the methods of investing which this study is focussed on.

Adjekophori (2014) examined the viability of pension fund as a veritable source of financing real estate development in Nigeria. The method adopted was convenient random sampling where He sampled 42 respondents comprising of 18 pension fund managers and 24 real estate developers and the data was analysed through simple descriptive statistics. His findings showed that pension fund is a viable real estate financing instrument but its performance is hindered by the restriction imposed by the investment regulation/guideline from PenCom. This study focussed differently from that of Adjekophori (2014) and that is one of the contributions to knowledge on pension fund and real estate investment financing in Nigeria.

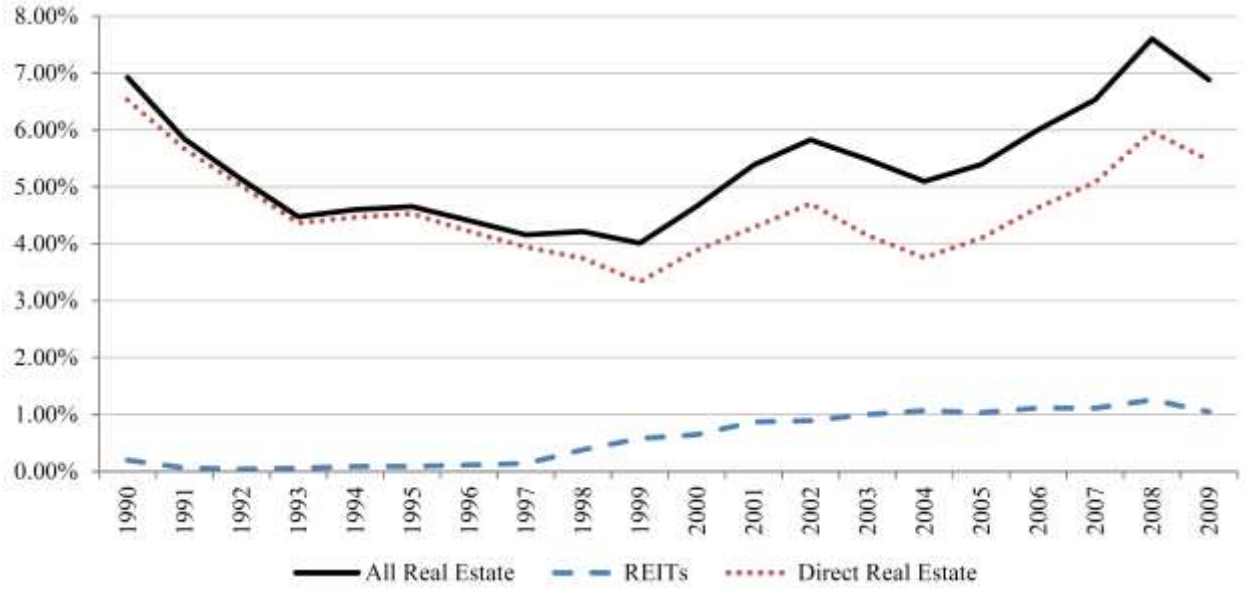
Eke *et al.* (2018) tested the relationship between investment in housing infrastructure and safety-equity factor in Nigeria's public pension fund management. They adopted ex post facto method of analysis from primary and secondary sources of data in their methodology. Their finding is that, investment of pension fund in housing infrastructure showed strong relationships with safety of funds and equity in the distribution of investment returns to the investors. Eke *et al.* (2018) focused on the relationship between investing in housing infrastructure and safety-equity factor of pension fund while this study focussed on the application of the methods of investing pension fund in real estate in Nigeria. This will give rise to determining the extent of the application of the methods of investing expressed in figures and percentages and to determine whether their difference is significant. The two methods of investing in focus are REIT and DREP.

Umeh and Okonu (2018) wrote on, "Real estate performance in Nigeria pension fund". The authors examined the contribution of real estate to the performance of mixed-asset portfolio of the Nigerian pension fund. They used descriptive statistics to analyse data on capital values collected from PenCom from 2007 to 2016. Their findings showed that, there is diversification benefit resulting from integrating real estate to other assets of the Nigerian pension fund, and that the fund's portfolio performed better when real estate is integrated in the mixed-asset portfolio. The focus of this study is different from that of Umeh and Okonu (2018) though both studies dealt on pension fund and real estate investment financing. The period of their study is 2007 – 2016 while that of this research is 2012 – 2021.

The few foreign studies known to this research that dealt closely on application of the methods of investing are Andonov *et al.* (2012), Andonov *et al.* (2013) and Andonov *et al.* (2015). In Andonov *et al.* (2012) the authors employed CEM database from 1990 – 2009 comprising of 884 U.S., Canadian, European Union and Australian/New Zealand pension funds to examine the performance of their investments in DREP and REIT in terms of their size and value added from intermediated money managers. In Andonov *et al.* (2013), the authors wrote on, "A global perspective on pension fund investments in real estate". They explored CEM database to study the real estate investment approach, cost, and performance for a global panel of 884 pension funds from the U.S., Canadian, European Union and Australian/New Zealand. In Andonov *et al.* (2015) the authors used CEM database and evaluated globally the economics of financial intermediation in alternative assets by investigating the allocation and performance of pension fund investments in real estate.

As can be seen in these three different studies, the authors used CEM database from 1990 – 2009 comprising of 884 U.S., Canadian, European Union and Australian/New Zealand pension funds and they broadly categorized the methods of investing into DREP and REIT. In pursuit of the focus of these three different studies, they authors ascertained the amount invested in DREP and REIT by the 884 pension funds. With the figures, they determined the extent of the application of the two methods (DREP and REIT) in the investing of pension fund which they expressed in percentages (see Figure 1, where REITs is the blue dotted line, DREP is the red dotted line and their total is the black thick line). What they did not do and which this present study intends to do is that, they failed to determine through statistically means whether the difference in the extent of the application between the two methods of investing is significant. This is the major gap from literature and this study intends to fill it by using the pension fund in Nigeria as a case study.

Figure 1: The application of REITs and DREP in the investing of pension fund in some selected countries around the world showing their percentage composition in the total pension fund assets.
Source: Andonov *et al.* (2015).



METHODOLOGY

Quantitative data sourced from PenCom were used to do this research. These are numeric figures comprising of the amount of pension fund available for investment annually. It also comprises of the amount of investment spending by pension fund annually in all the investment instruments. From these figures, the amount invested in the two real estate instruments (DREP and REIT) were sieved. The data was sourced from PenCom because, PenCom as the regulator aggregates and publishes on regular basis the activities of the pension fund managers in the investing and management of pension fund assets. The data was sourced through PenCom's official website. The period of study is 10 years from 2012 to 2021.

The figures from PenCom were deduced to achieve objective one of this study which is, to determine the extent of the application of the methods of investing pension fund in real estate financing in Nigeria. The extent of the application of the methods of investing are quantitative figures measured in Naira (₦) and also expressed in percentage (%). Findings from objective one was used to achieve objective two

through test of hypothesis which is, to determine whether the difference in the extent of the application of the methods of investing is significant.

Data is presented in tabular form. Objective one is analysed descriptively with percentages. Objective two is analysed inferentially with the aid of Independent Samples T-Test. The choice of Independent Samples T-Test is most appropriate because it is used when there is need to compare the mean scores of variables obtained from two independent groups. Atser and Ujene (2016) opined that it is used for testing the differences between the mean scores of two independent groups or samples.

FINDINGS

Objective one of this study is to examine the methods of investing pension fund in real estate financing in Nigeria to determine the extent of their application. The extent of the application (level of use) here implies the magnitude of pension fund invested in each real estate asset class. The extent of the application was determined based on the amount invested out of the available amount of pension fund for investment annually. The two real estate asset classes (methods of investing) are Real Estate Investment Trust (REIT) and Direct Real Estate Property (DREP) investment. The period under review is 2012 to 2021. The extent of the application is expressed in figures and percentages and presented in Table 1.

Table 1: The extent of the application of the methods of investing pension fund in real estate financing in Nigeria from 2012 to 2021.

Period	Available Amount for Investment (₦)	Asset Class and Amount Invested in ₦ and %			
		REIT (₦)	(%)	DREP (₦)	(%)
2012	745,090,000,000.00	-19,724,174,000.00	-2.65	43,120,000,000.00	5.79
2013	904,330,000,000.00	4,431,217,000.00	0.49	3,320,000,000.00	0.37
2014	554,180,000,000.00	-1,163,778,000.00	-0.21	21,180,000,000.00	3.82
2015	691,140,000,000.00	6,151,146,000.00	0.89	690,000,000.00	0.10
2016	861,880,000,000.00	6,205,536,000.00	0.72	19,700,000,000.00	2.29
2017	1,356,403,570,000.00	6,983,470,000.00	0.51	-30,991,450,000.00	-2.28
2018	1,122,384,790,000.00	-890,640,000.00	-0.8	26,353,870,000.00	2.35
2019	1,580,316,860,000.00	-4,441,750,000.00	-0.28	-9,702,500,000.00	-0.61
2020	2,088,099,710,000.00	73,939,600,000.00	3.54	-60,306,040,000.00	-2.89
2021	1,118,663,200,000.00	-856,140,000.00	-0.08	-2,908,100,000.00	-0.26
Total	**11,022,488,130,000.00**	**70,634,487,000.00**	**0.64**	**10,455,780,000.00**	**0.09**

Source: Compiled by the researcher using data from PenCom.

Year 2020 and 2014 recorded the highest and lowest available amount for investment respectively, and the average available amount for investment in the 10-year period under review is approximately ₦1.10 trillion. Year 2020 and 2013 recorded the highest and lowest investment in REIT respectively, while year 2012 and 2021 recorded the highest and lowest divestments respectively. The average investment

of pension fund in REIT during the period under review is ₦7.06 billion. Year 2012 and 2015 recorded the highest and lowest investment in DREP respectively, while year 2020 and 2021 recorded the highest and lowest divestments respectively. The average investment of pension fund in DREP during the period under review is ₦1.05 billion. During the period under review the highest extent of the application of REIT (3.54%) and DREP (5.79%) happened in 2020 and 2012 respectively. When aggregated the extent of the application of REIT and DREP during the period under review (2012 – 2021) are 0.64% and 0.09% respectively and their averages are 0.064% and 0.009% respectively too. Based on the findings it will not be wrong to conclude that the extent of the application of the methods of investing pension fund in real estate financing in Nigeria is poor during the period under review.

Having established the extent of the application of the methods of investing which showed that there are differences in the level of application, it became necessary to set objective two which is, to determine whether the differences are statistically significant. If the differences are statistically significant it implies that the extent of the application of one method is significantly more than the other. To achieve this objective hypothesis was tested.

The null hypothesis states that, there is no significant difference in the extent of the application of the methods of investing pension fund in real estate financing in Nigeria. Information in Table 1 was used to test this hypothesis by applying the extent of the application of the two asset classes expressed in percentages from 2012 to 2021. Independent Samples T-Test was used to test the hypothesis. The summary of the result is presented in Table 2. The decision rule is that, the null hypothesis is rejected when the probability value (significance) is less than 0.05. However, if the reverse is the case the null hypothesis is accepted. The summary of the result shown in Table 2 indicated that the p-value of the independent samples T-test which is 0.514 is more than 0.05. This suggests no significant result meaning that the null hypothesis is accepted. Therefore, it is proper to infer that, there is no significant difference in the extent of the application of the methods of investing pension fund in real estate financing in Nigeria.

Table 2: Result of T-test for difference in the extent of the application of the methods of investing pension fund in real estate financing in Nigeria.

		Levene's Test for Equality of Variances		**T-Test for Equality of Means**					
		F	**Sig.**	**t**	**df**	**Sig. (2-tailed)**	**Mean Diff.**	**Std. Error Difference**	**95% Confidence Interval of the Difference**
									Lower
Upper									
Extent of App.	Equal Var. Assumed	3.843	.066	-.666	18	**.514**	-.65500	.98413	-2.72258
1.41258									
	Equal Var. not Assumed			-.666	14.371	.516	-.65500	.98413	-2.76065
1.45065									

Source: Result of Independent Samples T-test.

DISCUSSION OF FINDINGS

Findings of this study showed that, during the period under review (2012 to 2021), the extent of the application of the methods of investing pension fund in real estate financing in Nigeria is poor. This is because the average extent of application for REIT and DREP are 0.064% and 0.009% respectively.

None of the two real estate asset classes (REIT and DREP) recorded up to 6% level (extent) of application annually. Emphatically, the highest annual level of application for REIT is 3.54% which occurred in 2020 while that of DREP is 5.79% which occurred in 2012. Furthermore, when aggregated during this 10-year period, none of the two real estate asset classes recorded up to 1% level of application (see Table 1).

As revealed by literature, the poor level of application is attributed to the challenges on investing. Some of the challenges of investing pension fund in REIT in Nigeria are; lack of wide availability of REIT in the Nigerian market, unavailability of viable REIT in the Nigerian market, and uncertainty in realizing adequate investment returns as a result of risks associated with the newness of REIT in the Nigerian market (Nubi and Adewunmi, 2011). Others are; underdevelopment of the REIT sector in Nigeria, underdevelopment of the Nigerian stock market where REIT is traded, stock market risk in Nigeria, lack of wide acceptability of REIT in the Nigerian market and lack of depth information on the structure and mechanism of REITs to the investing public (Ogunbanjo, 2017; Onyema, 2017).

Some of the challenges of investing pension in DREP in Nigeria are similar to the general problems of real estate development in Nigeria. They are, the problem of land acquisition due to high cost of land in the open market and the delay and corrupt practices shrouding land allocation by government (Adetokunboh *et al.,* 2013). According to Ugonabo and Emoh (2013) the problems include: bribery and corruption by government officials during; land allocation, land title registration, approval of building plan and discharge of development control functions. Other problems are: high cost of building construction, multiplicity of development charges and taxes, restriction by development control measures and delay and cost of land registration and titling (Ukoje and Kanu, 2014; Olofa and Nwosu, 2015).

The implication of the continued poor application of pension fund in real estate investment financing is that, the stock of real estate infrastructure in Nigeria will continue to be in deficit because the expected complimentary role by pension fund in investment financing is lacked. Another implication is that, the sources of real estate investment financing will continue to be scarce in Nigeria because the expected contribution in financing by pension fund is insignificant. Further implication is that, the contribution to Nigeria's GDP by the real estate sector would be reduced because of the minimal impact in the application of pension fund in real estate investment financing. That is, pension fund has not meaningfully contributed to Nigeria's GDP through the real estate sector.

Another obvious fact from findings is that, there was no clear pattern on the level of application of the two real estate asset classes. The level of application of the two real estate asset classes was neither on ascending or descending order but random from 2012 to 2021. In some years there were divestments instead of investments. The reasons for the above cases could be attributed to the need to maintain profitable portfolio balance at every point in time. This is achieved by divesting unprofitable, risky, and unviable real estate assets and securities and increasing the stock of viable ones.

This lack of pattern did not create a clear difference on the extent of the application of the two methods of investing pension fund in real estate financing in Nigeria. This necessitated objective two which was achieved through test off hypothesis where it was established that there is statistically no significant difference in the extent of the application of the methods of investing pension fund in real estate financing in Nigeria. It is obvious that, the lack of significant difference in application is attributed to the lack of pattern and randomness, where, in some years there were investments and other years divestments.

The poor extent of the application of the methods of investing as revealed by this research clearly supports the earlier view of Adjekophori (2014). The only minor difference is that Adjekophori (2014) formed his opinion on poor application based on the aggregate value of contribution of pension fund in real estate financing since commencement in 2004, while this study formed its opinion based on the percentage amount invested annually out of the available pension fund for investment from 2012 to 2021. Adjekophori (2014) was also silent on the application of REIT in the investing of pension fund.

That is, He isolated REIT and dwelt on the application of DREP in the investing of pension fund while this study dwelt on both REIT and DREP. Also, Adjekophori (2014) did not study the differences in the application of the methods of investing which this study did. This study also went further to determine that, the differences in the application of the methods of investing during the period under review (2012 to 2021) is not significant.

The findings of poor extent of application of the methods of investing also supports the earlier view of Nubi and Adewunmi (2011). The difference is that Nubi and Adewunmi (2011) studied MBS and REIT while this study dwelt on REIT and DREP. However, Nubi and Adewunmi (2011) failed to assert in clear terms that, MBS does not exist in Nigeria as an investment instrument because no MBS is enlisted at the stock exchange in Nigeria where it should be traded. They only wrote on the challenges hindering the application of MBS and REIT in the investing of pension fund in Nigeria, where they asserted that, the application of MBS is hindered by its unavailability as an investment instrument in Nigeria and the application of REIT is majorly hindered by underdevelopment of the REIT sector in Nigeria.

CONCLUSION AND RECCOMMENDATIONS

The findings of this research formed the basis for drawing a number of conclusions. It is concluded that the application of the two real estate asset classes in the investing of pension fund in Nigeria is poor. The application lacked pattern neither in ascending nor in descending order. The difference in application between the two asset classes is not significant. If the poor application of the two real estate asset classes in the investing of pension fund is not redressed, the consequence is that the performance of pension fund in real estate investment financing in Nigeria will continue to be dismal.

In view of the foregoing, it is recommended that, the pension fund managers (PFAs and CPFAs) should increase investments in real estate using the two presently available instruments (REIT and DREP). It is recommended that PenCom should advise SEC, NSE and other relevant bodies to liaise together to ensure that REIT becomes widely available as an investment instrument in Nigeria. It is recommended that pension fund managers should sustainably be increasing investments in DREP to check its decline as revealed by findings. PenCom should allow retirement savings of Defined Contributory Schemes (DCS) to invest in DREP. It would be recalled that, the investment regulation and guideline from PenCom only permitted retirement savings of Defined Benefit Schemes (DBS) to invest in DREP. It would also be recalled that, the DBS is gradually been wound up in Nigeria. Findings showed that the gradual winding up caused the declining application and performance of DREP asset class. The continued restriction of DCS from investing in DREP implies that DREP asset class would gradually be phased out as an investment instrument in Nigeria. Why allow an asset class that performs well to gradually phase out? If it were not to be a viable instrument it would not have been performing well.

Finally, it is suggested that, in the future, this study should be repeated using the same variables and by then covering an elongated period of time to see whether there will be any difference in findings. Furthermore, it is suggested that, in the future, this study be repeated by other researchers using different statistical analysis techniques to see if there will be any difference in findings.

REFERENCES

Adetokunboh, O., Aibinu, I. and Agbato, S. (2013). Corporate real estate development in Nigeria: Issues and challenges of site acquisition. *African Real Estate Society Conference,* Kigali, Rwanda, 23rd – 26th, October, 2013.

Adjekophori, B. (2014). Pension fund: a veritable source of financing real estate development in Nigeria. *International Letters of Social and Humanistic Sciences,* 23: 23 – 40.

Afrane, S.K., Owusu-Manu, D., Donkor-Hyiaman, K.A. and Bondinuba, F.K. (2014). Towards innovative housing financing in Ghana: an evidence-based from South Africa's pension housing financing system. *Public Policy and Administration Research,* 4 (4): 97 – 110.

Andonov, A., Eichholtz, P. and Kok, N. (2012). *Value added from money managers in private*

markets? An examination of pension fund investments in real estate. Working Paper, Maastricht University. https://www.reri.org/research/article_pdf/wp182.pdf (Retrieved on 3rd May, 2019).

Andonov, A., Kok, N. and Eichholtz, P. (2013). A global perspective on pension fund investments in real estate. *The Journal of Portfolio Management*, 39 (5): 32 – 42.

Andonov, A., Eichholtz, P. and Kok, N. (2015). Intermediated investment management in private markets: evidence from pension fund investments in real estate. *Journal of Financial Markets*, 22 (C): 73 – 103.

Atser, J. and Ujene, A. (2016). *Computer Approach to Inferential Statistics.* Parvenu Technologies, Uyo, Akwa Ibom State.

Eke, O.A., Ndubuisi, P. and Eleagu, G.I. (2018). Public pension asset and investment in housing infrastructure: rethinking the safety-equity net in Nigeria. *Global Journal of Arts, Humanities and Social Sciences*, 6 (8): 43 – 63.

Farrelly, K. and Moss, A. (2014). Blending public and private real estate allocations for defined contribution pension funds: a U.K. case study. *The Journal of Real Estate Portfolio Management*, 20 (3): 137 – 150.

Federal Republic of Nigeria (2014). *Pension Reform Act, 2014.* Federal Government Printer Lagos.

Moss, A. and Farrelly, K. (2015). The performance of a blended real estate portfolio for UK DC investors. *Journal of Property Investment and Finance*, 33 (2): 156 – 168.

National Pension Commission (PenCom) (2011). *Guidelines on Direct Real Estate Investments by Closed Pension Fund Administrators and Approved Existing Schemes.* https://www.pencom.gov.ng/wp-content/uploads/2017/04/Guidelines_on_Direct_Real_Estate_Investment_by_CPFAs_and_AES1.pdf (Retrieved on 2nd May, 2018).

Nubi, T.O. and Adewunmi, Y.A. (2011). Issues influencing access of pension funds as a housing finance instrument in Nigeria. *Journal of Contemporary Issues in Real Estate*, 1(1).

Ogunbanjo, A. (2017). A keynote address presented at the maiden conference on Real Estate Investment Trusts (REITs) with the theme: "Real estate investment in Sub–Saharan Africa – the role of the capital market", hosted by the Nigerian Stock Exchange in Lagos, on 23rd May, 2017.

Olofa, S. and Nwosu, A. (2015). Investigating the problems associated with public-private partnership in the process of housing delivery in Nigeria. *International Journal of Education and Research*, 3 (1): 123 – 130.

Oni, A.O. (2013). Money market indicators, pension funds, and real estate finance in Nigeria. *African Real Estate Society Conference*, held at, Lemigo Hotel, Kigali, Rwanda, 22nd – 24th, October, 2013.

Onyema, O.N. (2017). A welcome address presented at the maiden conference on Real Estate Investment Trusts (REITs) with the theme: "Real estate investment in Sub–Saharan Africa – the role of the capital market", hosted by the Nigerian Stock Exchange in Lagos, on 23rd May, 2017.

Ugonabo, C.U. and Emoh, F.I. (2013). The major challenges to housing development and delivery in Anambra State of Nigeria. *Civil and Environmental Research*, 3 (4): 1 – 19.

Ukoje, J.E. and Kanu, K.U. (2014). Implementation and the challenges of the mass housing scheme in Abuja, Nigeria. American International Journal of Contemporary Research, 4 (4): 209 – 218.

Umeh, O.L. and Okonu, A.A. (2018). Real estate performance in Nigeria pension fund. Journal of Property Investment & Finance, 36 (5): 454 – 465.

CITY PROSPERITY INDEX AS A TOOL FOR URBAN REGENERATION: A CASE STUDY OF IBADAN, NIGERIA

[1]Segun Okunola, [2]Enoch D. Odesola, [3]Bola Ogunbodede
[1]Department of Architecture, University of Lagos, Nigeria
ookunola@unilag.edu.ng
[2]Leicester School of Architecture, Architecture Research Institute
de Montfort University, Leicester, United Kingdom
odesolaenoch@gmail.com
[3]Department of Architecture, University of Lagos, Nigeria
bogunbodede@unilag.edu.ng

ABSTRACT
The need to establish the social, economic, and environmental sustainability aspect of cities cannot be overemphasized. However, urban regeneration projects are not new to urban centres, several studies have revealed the shortcomings associated with the study of the methods to ensure urban regeneration practices and their planning processes are sustainable. This study examined some well-developed strategies for sustainable urban growth within Ibadan city. The method of data collection for this study was qualitatively structured to acquire pertinent data for the assessment of the current state of Ibadan city prosperity. Findings established that Ibadan city lacked community cohesion, poor civic identity, varying degree of security threats, poor mobility and connectivity consequent upon poor standard of living of the populace. Urban growth has not been properly managed in the city as shown by the study. The needs for planning process that can curtail, manage, and ultimately create satisfaction for its citizenry is recommended for Ibadan city.
Keywords: *City, Development, Growth, Planning, Prosperity Index, Space, Urban Regeneration,*

1.0 INTRODUCTION

A complex interwoven system of various social, cultural, economic, ecological and other processes within urban space is defined as the city. This Interaction can be grouped into two classifications; socio-economic or other processes that call for certain spatial configurations while space may either positively or negatively catalyze certain activities (Parsa, 2017). The city is a powerful and wonderful construct of history that developed in response to geographical forces that are now well understood, as the main keys to urban prosperity (Hassanali & Ali, 2021). However, prosperity is more than fulfilling basic needs, particularly urban prosperity is more than combating urban problems. Thus, the City Prosperity Index (CPI) is essential basis to discover and promote a new pattern or model of urbanization in the global scale which is adaptive to the contextual conditions and dynamics of individual cities (Ugis, K˛estutis, Sandra, Alisa, & Jurate, 2020). However, one of the key issues in relation to the city prosperity index is the weights of the dimensions and sub-dimensions in terms of the conceptualizations of a prosperous city based on local priorities and by extension - peculiarities (Gieseking, 2013).

The city requires a process, more diverse and a compliment vibrant neighbourhoods and one in which extend those positive impacts will extend into the wider city-scale which can be achieved through urban regeneration (Ellis & Roberts, 2016). This is an integrated and inclusive process that combines physical, environmental, and socio-economic measures (Feldman, 2014). Urban regeneration has been recognized as one of the most comprehensive and effective tools that governments can adopt to promote more inclusive, resilient, safer, and sustainable cities (Kitchin, Lauriaulta, & McArdle, 2015). Urban dynamics look at urban regeneration through an adjusted lens, which encompasses urban health and post-pandemic recovery, climate change adaptation and mitigation, shifting notion and products of culture and digital transformation (Wong, 2015). These dynamics may be perceived as challenges within the urban environment, but they also represent significant opportunities. Regeneration processes require innovative approaches and financing, as well as complex, inclusive and sustainable policies that counteract the realities of displacement and speculation, historically associated with urban renewal strategies (Bank, 2013).

2.0 LITERATURE REVIEW

2.1 Prosperity is one of the most widely followed themes by policy makers, planners, scholars and entrepreneurs. Prosperity has been described as a condition of physical and material security combined with personal and social well-being (UN-Habitat, 2013). The key determinants of prosperity are prevailing economic conditions which are linked to productivity. Efforts to transform cities into better places to live have always been the main concerns of urban management (Stead, 2015). UN-Habitat put forward a comprehensive and integrated approach called city prosperity, which pursues a path beyond sustainable urban development (UN-Habitat, 2013). In addition to sustainable development, it also has the happiness, prosperity, vitality, dynamism and quality of urban life (Colantonio & Dixon, 2010).

City Prosperity is a wheel in the centre of which government institutions, urban planning laws and regulations, infrastructure, environmental sustainability, quality of life, justice and urban equity revolve (UN-Habitat, 2016). Prosperity is a widespread concept associated with balanced and harmonious development in an environment of fairness and justice. Accordingly, city prosperity is a kind of social construction that enables human activities (UN-Habitat, 2019). City prosperity examines how cities can produce and how the benefits of this production can be distributed in a fair way among its citizens. This thinking involves economic growth, the rule of social relations, environmental sustainability and a better quality of life (Akhundi, Sohrabi, & Azimzadeh, 2015).

2.2 City Prosperity Index (CPI)

In 2012, UN-Habitat created a tool to measure the sustainability of cities (Salami, Giggins, & Von Meding, 2017). This tool known as the city prosperity index was accompanied by a conceptual matrix, the Wheel of urban prosperity in terms of five key components namely:- productivity, infrastructure development; quality of Life; equity and social inclusion, environmental sustainability. A sixth component was added later which is governance and legislation (Ugis, K, estutis, Sandra, Alisa, & Jurate, 2020). An equitable prosperous sustainable city was based on productive, resilient, safe and healthy, inclusive, green and planned city (UN-Habitat, 2013). The city prosperity index was transformed into a global initiative known as the city prosperity initiative (CPI) and sets out a framework whereby the relationship between urban prosperity, the factors influencing and, ultimately, influenced by it can be viewed (Smith, 2012).

This initiative is both a metric index and a policy dialogue, which offers cities from developed and developing countries the possibility to create indicators and baseline information, targets, and goals that can support the definition of ambitious and measurable city-visions and long-term plans (Akotia, Alex, & Farahat, 2017). The city prosperity initiative (CPI) as a global monitoring framework for the urban sustainable development goals (SDGs), is an integral part of the data revolution for sustainable development (Akerele, 2011). It not only aims at the integration of new sources of data and the increase in the usefulness of information, but also enables city authorities, as well as local and national stakeholders, to identify opportunities and potential areas of intervention for their cities to become more prosperous. While there is need for choosing the best and most sustainable options and alternatives, the CPI can play a vital role in this regard (Colantonio & Dixon, 2010).

2.3 Urban Regeneration

Regeneration is the primary instrument of western cities to inflect the extant urban form. The term is not only peculiar to urbanism but it shares biological and religious nuances. In the biological sciences, urban regeneration pertains to the re-creation of organic life while it invokes rebirth in the region (Gieseking, 2013). However, both expressions related to the field of urbanism. The prefix 're', has a Latin extraction and it is inseparably linked with connotations of a new life for the targeted areas, depending on the context and definition of regeneration. Urban regeneration is a term linked to a wide range of processes affecting the urban environment (Ugis, K, estutis, Sandra, Alisa, & Jurate, 2020). Urban Renewal. Alongside its physical components, urban regeneration creates significant social, communal, environmental, and economic impacts resulting from changes to the built environment, as well as veteran residents move out or new residents moving in to renewed or regenerated complexes (UN-Habitat, 2019).

The idea of urban regeneration began in the 80's and connotes more than just demolishing and rebuilding (Tallen, 2013). Its definition has evolved over time and has been heavily influenced by nation of sustainability, enhancing property values, encouraging entrepreneurship and attracting private ventures. It has therefore been argued that new sustainable communities can propel urban regeneration and sustainable communities are therefore vital elements of any regeneration structure (McDonald *et al.*, 2009).
Roberts (2000)offered an interesting definition of urban regeneration as "the comprehensive and integrated vision and action which leads to the resolution of urban problems which seeks to bring about lasting improvement in the economic, physical, social and environmental condition of an area that has been subject to change" See Figures 2 and 3. However, this definition is countered by Turok (2005), he pointed out that regeneration is hardly comprehensive and that urban problems addressed are not fixed in practice as they can be part of the most obstinate or 'wicked' issues in society. It was also pointed out that Roberts' assertion that urban regeneration can bring about "lasting improvement" is over ambitions as it runs counter to the natural course of constant transformation of the urban environment that continuously possess new challenges and prospects that requires adaptation.

The development of planning relationship and urban development is being shaped by globalization processes and urban competition, this has seen urban regeneration policies taken a new form. However, in practice, urban regeneration processes are influenced by physical policies and top-down managerial approach in Nigeria, therefore attention must be paid to transnational scale and entrepreneur approaches to facilitate these processes (Wong, 2015). Urban regeneration offers the reconstruction, recreating, and renewal of existing urban areas. It calls attention to adapting new approaches in reconstructing certain areas (Colantonio & Dixon, 2010). Urban regeneration is a comprehensive and integrated approach which seeks to bring about a lasting improvement in the physical, economic, social and environmental conditions of an area that has been subject to change (UN-Habitat, 2013). The salient urban regeneration features are social, economic, and environmental. Urban regeneration is a spatial, economic and social intervention. On the contrary, urban regeneration can be a concise synergy of ad hoc and fragmented physical projects for wider city development (Akotia, Alex, & Farahat, 2017).

2.4 **Study Area**

The mid-1800s marked the creation of Ibadan city, the prosperous oil economy in the year 1970s marked the beginning of its urban spur. The transformation of Ibadan into a multi-cultural city welcomed a large population migration (Adelekan, Olajide-Taiwo,, Ayorinde, Ajayi,, & Babajide, 2014). The geographical location of Ibadan possibly facilitated it becoming the largest city in Nigeria and the third-largest in Africa after Cairo and Johannesburg. Regrettably, its geographical area ranking does not count for its prosperity. It is established that the population growth is over 100,000 every year resulting from migration and natural increase (Adriano, 2018). Ibadan is characteristically of mixed collection or cluster of buildings that cannot be categorized into a particular pattern. Although the city witnessed developmental growth without a plan. The national economic growth has impacted the city, leading to urban expansion without any concrete pattern nor noticeable development in the city at large (Akerele, 2011) (See Figure 1).

Figure. 1; Map of Nigeria showing Ibadan City

The uncoordinated development experienced in the city has resulted sub-urban slums. Urban development is not a new experience in Ibadan city, although it has been done at the detriment of the existing buildings, regulations that supposed to create and sustain an environment (Akintoye, 2010). It is visible that building plans were not approved before the buildings were constructed viewing the city from satellite imagery. This inadequacy plan generates informal settlements and slums as witnessed in the city (Salami, Giggins, & Von Meding, 2017). This causing managerial problems in the development and regeneration of the urban areas. This unplanned urban development often takes a toll on the holistic well-being of the city. City infrastructure become over stretched to meet the ever-increasing population. Informal settlement in Ibadan has led inadequacy of infrastructure in the city of Ibadan. The city of Ibadan is experiencing deplorable state of infrastructure (Johnson, 2010) due in large part to uncoordinated planning, haphazard development and population explosion (See Figures 2 and 3).

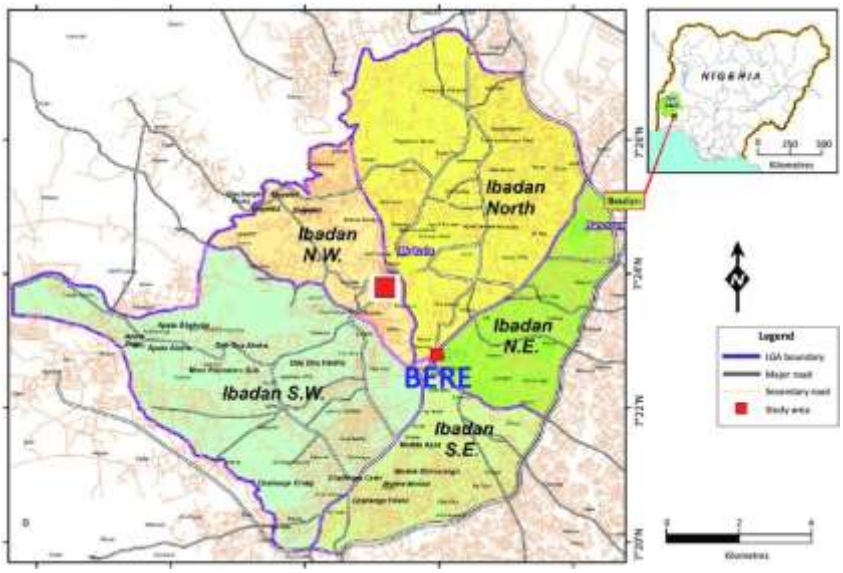


Figure 2: Map of Ibadan City Core Area

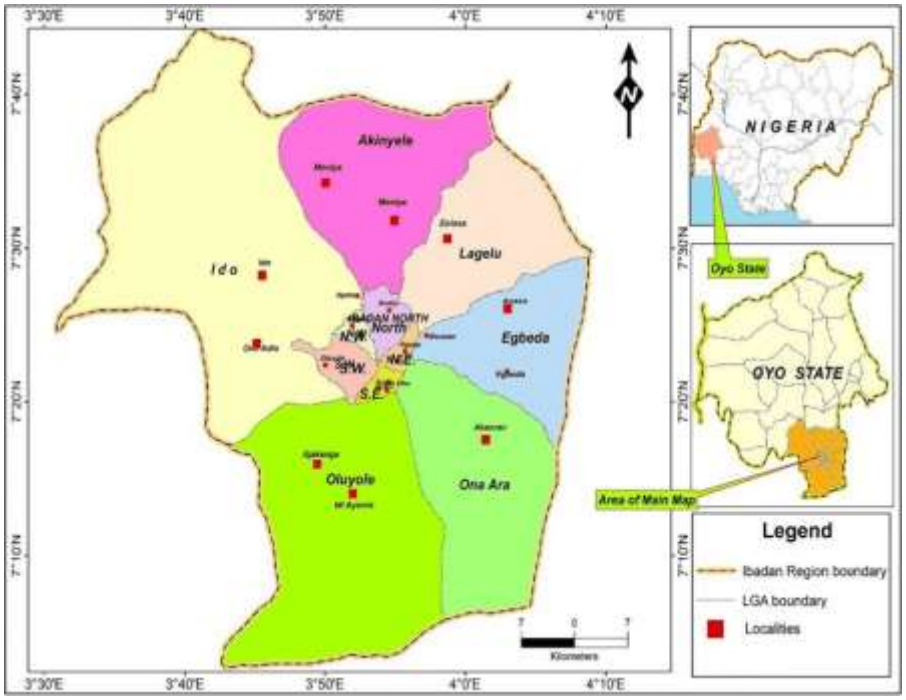


Figure 3: Map of Ibadan City showing major Clusters

3.0 METHOD

Data collection for this study was qualitatively structured to acquire pertinent data in the inquiry for the assessment of the current state of Ibadan city prosperity. The study collected relevant data from various focus groups discussion using a semi-structure questionnaire, stakeholders' interview, survey observation and mapping. The focus group discussions were organized to obtain all relevant data on the city's current state decayed, the dimension of urban prosperity operationalized, development of a city prosperity index (CPI), relative contribution of urban prosperity.

This study analyzed relevant data collected on decayed urban features, productivity, infrastructural development, quality of life and environmental sustainability from various focus group discussions using a semi-structure questionnaire, stakeholders' interview, survey observation and mapping using an appropriate computer qualitative data assisted software (CQDAS). The dimensions of urban prosperity operationalized were considered using city decayed, productivity, infrastructural development, quality of life and environmental sustainability.

4.0 RESULTS AND DISCUSSIONS

4.1 Decayed Urban Features

Urban decay in Ibadan can be best described as the image of deterioration manifestation of the areas prompted by poverty and the low capacities of dwellers to effect expensive repairs. Buildings and roads were in deplorable state. Many of the buildings were assessed through footpath. Majority of the roads were without drainage system, lacked furniture with narrow width exceeding its carrying capacity. The vegetal quality of the city diminished steadily with city growth and the haphazard development without any consideration for city greenery. The urban decay of Ibadan city is a factor of poor urban growth related to urban lateral expansion against vertical expansion as a crusade by the developed world.

Plate 1: Deplorable road condition *Plate 2: Development in the swamp area*

Again, the price of land in the study area is seen as a factor contributing to urban decayed. The city's core areas were without infrastructural facilities and characterized by the urban poor with low land prices available for the poor citizenry. In addition, swamp areas and family allotments within the core areas are often available for poor people. The land in possession of family holdings is usually made available for the interested family members for whatsoever purpose(s) to either build, rebuild or partition. Evidences of uncoordinated development abound in the swamp area.

Plate3: Google image showing brown roof *Plate 4: Dilapidated Buildings*

4.2 Urban Productivity

Productivity is a mechanism to record cities' wealth and economic contribution to the overall growth and development. Ibadan urban productivity is described as poor by the discussants and marked with decreasing productivity. The city lacked policies and legislation for urban productivity, suffered high unemployment rate and characterized by petty trades activities resulting to on street trading as a means of livelihood. The city experienced poor spatial distribution of economic activities. Thus, is reflected in the mean household income of the citizenry of Ibadan. It must be maintained that the dependent ratio in the city keeps on increasing as the employment to population ratio is widening on daily basis. However, the city lacked the power to create new jobs within the present information technology age dispensation and thereby broadening the unemployment gap. It was established that the city of Ibadan's productivity dimension is very poor. As a result, it affected the urban prosperity dimension adversely. The city under investigation's prosperity is poor as the city's productivity is abysmal. The employment rate in the city is considered very poor, and the economic agglomeration indication is considered to be very weak.

Plate 5: On-Street trading

Plate 6: Deplorable condition of the city

4.3 Urban Infrastructure

Ibadan city infrastructure measurement is described as very poor considering the city's present situation. The city of Ibadan, going by the convergence of views of the discussants, established that it was not able to harness its resources for functional and efficient infrastructure. It was noted that physical assets and amenities like electricity power supply, potable water, wastewater, solid waste, ICT and road network were not able to support the ever-increasing population of the city. The result then reflected on the poor economic condition and poor quality of life of the citizenry. The city's strength in housing infrastructure development is believed to be very poor as housing is not within reach of the average people in the city. The social infrastructure of the city is considered to be very poor, coupled with a poor level of environmental sanitation, as it was observed during the field survey. It was also observed that the connectivity of the street is poor and lacked legibility.

Plate 7: Road with furniture

Plate 8: Public well

Plate 9: Piles of solid waste

4.4 Environmental Sustainability

The findings also indicated that Ibadan is not environmentally sustainable. The city is faced with numerous challenges such as erratic power supply to drive information and communications technology; environmental pollution is prevalent in the city from various fumes released by electricity generating sets and automobiles, resulting in a high level of CO_2 emission with its health implications, inability to recycle waste generated by the increasing city population. Loss of green areas was evident in the study area as most of the green has been converted to other uses as a result of the increase in the demand for land for varying activities as posed by the population, which has a significant threat on the environment at large. The road network system is characterized by deplorable conditions leading to traffic congestion and social vices on these roads. However, this has caused the loss of man-hours in

Ibadan, resulting in poor productivity performance of the people. Additionally, the city lacked a potable water system as most of the citizenry used the public well system except for the few affluent in society and this surely will have negative health implications. It was also noted that the wastewater system is in a bad state and needs urgent attention as gullies were evident in the study area, which also have negative impact on wellbeing of the citizens. Concerning all these factors, it can be deduced that the city of Ibadan has no mechanism for an effective or efficient environmentally sustainable plan or program for this city and so the picture is that of a city that appears to be left on its own-uncatered for (See Figure 4).

Figure 4: Environmental sustainability

4.5 Quality of Life

The measure of achievements through the quality-of-life value in providing basic amenities to enhance happiness and overall welfare of the people in Ibadan is poor relative to the urban prosperity. It was noted that Ibadan as a city is not self-prosperous, sign posting a poor quality of life of the people. The poor quality of life in the study area deprived the populace of the avenue to maximize individual potential in achieving fulfilling lives. The city lacked appropriate intervention and policies to enhance the quality of life that translated to urban prosperity. The poor quality of life of the people in the study area was caused by a lack of good healthcare facilities, insecurity, loss of greenery, poor educational system, poor road network system, pollution, lack of potable water systems and wastewater systems (See Figure 5).

Figure 5: Quality of life of the citizenry

However, the poor quality of life can be connected to poor health care system, filthy environment, poor wastewater and potable water system, poor solid waste management system, poor road, lack of infrastructure, and a host of other essential services to serve the city. It was observed that neglect in education is yet another factor attributing to poor quality of life in the study area, as discussed above. Safety and security of life and property are porous in the city as an issue of security is a national threat, particularly affecting the study area. Kidnapping, banditry, communal clash, Boko Haram and herders were significant security in this city that required urgent attention.

5.0 CONCLUSION

Ibadan city prosperity index indicators were measured through urban decay**, productivity, infrastructural development, quality of life and environmental sustainability.** The city prosperity dimensions in the city of Ibadan is weak. Ibadan experienced decay on every sphere of existence and characterized by poor productivity. The city's infrastructure is also weak, the resources for functional and efficient infrastructure were not harnessed accordingly. Physical amenities such as electricity, water, ICT, transport and road networks were deficient. The unemployment gap is broad and poor spatial distribution of economic activities can be observed around the city. Ibadan city fabric consists of many dilapidated buildings, sprawl, congestion and kiosk. Quality of life is poor, security also raised a significant consideration in the light of kidnapping, banditry and killings, which require attention. Environmental sustainability is weak, high-lightening environmental pollution as a frequent occurrence in the city with an inability to recycle waste generated. These challenges were stated as reasons for Ibadan not to be considered environmentally sustainable. There is need to improve on environment quality, promote mental image, tourism development, facilitate rules and regulations, attention to local creativity, and efficient and transparent management are of great importance to the city of Ibadan. The needs for planning process that can curtail, manage, and ultimately create satisfaction for its citizenry is recommended for Ibadan city. Given the performance of the variables of the city prosperity index as enunciated in this study and given that the overacting goal of urban regeneration what is to bring about 'lasting improvement' through a comprehensive and integrated vision action with a view to the resolution of urban problems. Therefore, there is an urgent need to craft policies and bold actionable steps to address factor will ultimately improve the outcomes of the variables for the benefit of the city at large.

REFERENCES

A Framework for 'City Prosperity Index': Linking Indicators, Analysis and Policy. (2015). *Science Direct*, 3-9.

Adelekan, I., O.-T. L., Ayorinde, A., A. D., & Babajide, S. (2014). Building Urban Resilence: Assessing Urban and Peri-Urban Agriculture in Ibadan, Nigeria. I. In N. Padgham, & J. Jabbour, *United Nations Environment Programme (UNEP).* Nairobi, Kenya: UNEP.

Adriano, M. M. (2018). *Death and the King;'s Horseman.* Universidade Federal do Rio Grande do Sul, Instituto de Letras, Programa de Pós-Graduação em Letras, Estudos de Literatura, Literaturas Estrangeiras Modernas.

Adriano, M. M. (2018). *Death and the King;'s Horseman.* Universidade Federal do Rio Grande do Sul, Instituto de Letras, Programa de Pós-Graduação em Letras, Estudos de Literatura, Literaturas Estrangeiras Modernas.

Akerele, W. (2011). *Efficiency of Urban Informal Sector Manufacturing Enterprises in Ibadan City, Nigeria.* Ibadan: NISER.

Akerele, W. (2011). *Efficiency of Urban Informal Sector Manufacturing Enterprises in Ibadan City, Nigeria.* Ibadan: NISER.

Akhundi, A., Sohrabi, A. , & Azimzadeh, M. &. (2015). Information Technology, urban regeneration, and local identity; A comparative study of preparation for the 2012 London Olympics and Paralympics and the Kyoto City Recovery Plan. *Journal of architecture and urbanization*, 5-24.

Akintoye, S. (2010). *History of the Yoruba People.* Dakar: Amalion Publishing.

Akintoye, S. (2010). *History of the Yoruba People.* Dakar: Amalion Publishing.

Akotia, J., Alex, O., & Farahat, H. (2017). The Extent of Practitioners' Involvement in the Delivery of Sustainable Urban Regeneration Projects in UK. *European Journal of Sustainable Development* , 147-164.

Arefi, M. (2014). *Deconstructing Placemaking.* New York: Routledge.

Ayobami, A. P., & Hangwelani, H. M. (2020). The Dilemmas of Rural Planning and Planners in Oyo State, Nigeria. *Bulletin of Geography. Socio_Economic Series*, 76-89.

Bank, W. (2013). *World Development Indicators.* Washington, DC: World Bank.

Carvalho, L., & Winden, W. (2017). Planned Knowledge Locations in Cities. *International Journal of Knowledge-Based Development*, 47-67.

Colantonio, A., & Dixon, T. (2010). *Urban Regeneration and Social Sustainability: Best Practice from European Cities.* Chichester, West Sussex, UK: Hoboken, NJ: Wiley-Blackwell.

Cooke, P. (2017). Complex spaces. *Journal of Open Innovation*, 9-11.

Duygu, G., & Fei, C. (2021). Multimodal and Scale-Sensitive Assessment of Sense of Place in Residential Areas of Ankara, Turkey. *Journal of Housing and the Built Environment* , 1077–1101.

Elia, G., Petti, C., & Sarcina, A. (2016). Promoting Communities of Innovation. *International Journal of Knowledge-Based Development*, 207-224.

Ellis, P., & Roberts, M. (2016). *Leveraging Urbanization in South Asia-Managing Spatial Transpormations for Prosperity and Livability.* Washington, DC: World Bank.

Feldman, M. (2014). The character of innovative places: entrepreneurial strategy, economic development, and prosperity. *Small Business Economics*, 9–20.

Gieseking, J. (2013). Where We Go from Here. *Qual. Inq.*, 712–724.

Gokce, D. (2017). *An empirical investigation of the interplay between typo-morphological transformation of house form and sense of place.* PhD Thesis, School of Architecture, University of Liverpool.

Hassanali, F. S., & Ali, H. (2021). Spatial Hetrogeneity Modeling of City Prosperity Using GWt-Test: The Case Study of Tehran. *Habitat International*, 1-7.

Jiboye, A. D., & Ogunshakin, L. (2010). The Place of the Family House in Contemporary Oyo Town, Nigeria. *Journal of Sustainable Development*, 117-.

Johnson, S. (2010). *The History of the Yorubas.* Cambridge: Cambridge University Press.

Johnson, S. (2010). *The History of the Yorubas.* Cambridge: Cambridge University Press.

Kitchin, R., Lauriaulta, T., & McArdle, G. (2015). Knowing and governing cities through urban indicators, city benchmarking and real-time dashboards. *Regional Studies, Regional Science*, 6–28.

Makkonen, T., & Weidenfeld, A. (2016). Knowledge-based urban development of cross-border twin cities. *International Journal of Knowledge-Based Development*, 389-406.

Nyoman, S. W. (2019). Opportunity to use City Prosperity Index for Indonesian Municpal Development Planning Process. *Geographia Technica,* 108 to 117.

Parsa, A. (2017). City Prosperity Initiative Index: Using AHP Method to Recalculate the Weights of Dimensions and Sub Dimensions in Reference to Tehran Metropolis. *European Journal of Sustainable Development*, 289-301.

Parsa, A. (2017). City Prosperity Initiative Index: Using AHP Method to Recalculate the Weights of Dimensions and Sub-Dimensions in Reference to Tehran Metropolis. *European Journal of Sustainable Development*, 289-301.

Salami, R., Giggins, H., & Von Meding, J. (2017). Vulnerability of human settlements to flood risk in the core area of Ibadan metropolis, Nigeria. *Journal of Disaster Risk Studies*, 1-14.

Salami, R., Giggins, H., & Von Meding, J. (2017). Vulnerability of human settlements to flood risk in the core area of Ibadan metropolis, Nigeria. • *Salami, R., Giggins, H. and von Meding, J., 2017. Vulnerability of human settlements to fJàmbá: Journal of Disaster Risk Studies*, 1-14.

Sanjeev, K., & Krishna, K. D. (2021). A Grounded Theory Approach for the Assessment of Urban Development Policies in Indian Cities. *Current Science*, 1561-1571.

Smith, A. (2012). *Events and urban regeneration: the strategic use of events to revitalize cities.* Routledge.

Stead, D. (2015). What does the Quality of Governance Imply for Urban Prosperity? *Habitat International*, 64-69.

Surabhi, P. (2018). *A Conceptiual Approach for Place Making in Knowledge and Innovation Spaces: Case Investigations from Brisbane, Melbourne and Sydney.* Submitted in fulfilment of the requirements for the degree of Doctor of Philosophy (PhD), School of Civil Engineering and Built Environment Science and Engineering Faculty Queensland University of Technology.

Ugis, B., K˛estutis, Z., Sandra, T., Alisa, K., & Jurate, K. (2020). Digital Information Tools for Urban Regeneration: Capital's Approach in Theory and Practice. *Sustainability*, 1-16.

UN-Habitat. (2013). *Cities Prosperity Initiative Toolkit.* World Urban Campaign Secretaria.

UN-HABITAT. (2013). *State of the World's Cities 2012/2015 - Prosperity of City*. USA: Routledge.

UN-Habitat. (2016). *Measurement of City Prosperity: Methodology and Metadata.* United Nations Human Settlements Programme (UNHSP).

UN-Habitat. (2019). *City Prosperity Innitiative.* Nairobi: UN-HABITAT.

Witt, U. (2016). What kind of innovations do we need to secure our future? *Journal of Open Innovation*, 1-17.

Wong, C. (2015). A framework for 'City Prosperity Index': Linking indicators, analysis and policy. *Habitat International*, 3–9

Zeyun, L., & Sharifah, R. S. (2016). Assessing the Driving Forces Influencing World City Formation in Shanghai Based upon PLS-SEM Approach. *Academic Journal of Interdisciplinary Studies*, 416-423.

SURVEY OF WASTE WATER TREATMENT AND RECYCLING IN ABUJA CAPITAL CITY NIGERIA

Y.A. Bature[1], P.U. Ogar[2], D. Papi[3] and Jacob Atser[4]
[1]Department of Urban and Regional Planning, University of Jos Nigeria
[2]Service Policies and Strategies Office; OHCSF, Abuja
[3]Department of Plant Science Technology, University of Jos Nigeria
[4]Department of Urban and Regional Planning, University of Uyo, Nigeria
baturey@unijos.edu.ng; pascogar@yahoo.com; danladiy@unijos.edu.ng; jacobatser@uniuyo.edu.ng

Abstract
Wastewater planning has become an inherent challenge in cities of developing countries where urban environment is compounded with increase growth rate of urban population with corresponding increase in volumes of wastewater generation. This constitutes the basic determinants of poor hygiene and environmental degradation. With the current world population of 7.5billion with about estimated 50% of population becoming urbanized, urban environmental hygiene and sanitation has become a growing concern. This research examines Waste Water Treatment Plants (WWTPs) and their recycling system in Nigeria's most modern capital city of Abuja. The sources of data involved the primary and secondary types. The primary data was acquired through the administration of questionnaire to 320 households in 5 neighbourhoods of Abuja CBD, Garki, Maitama, Asokoro and Bwari while the secondary data was derived from the official records of WWTPs. Descriptive statistics were used to present and analyse the data. The findings revealed that the discharged sewerage (51%), food remnants (32%), waste canned (15%) and other waste effluents (2%) had a total fallback service rendered of (63%) recycling threshold capacity. Although the 15 WWTPs had combined installed capacity of 900,000litres per day, only 230,000litres per day of wastewater were treated and discharged and this gives a usage capacity of ***25.56%****. Of the 15 waste water treatment plants, only 2 were functional at 40% and 30% capacities. This implies a rather weak performance and does not portend sustainable approach. The households in the 3 neighbourhoods of Abuja CBD, Garki and Maitama had full connection (100%) to Wastewater Pipeline Circuit (WPC). Asokoro and Bwari neighbourhoods however had 82.81% and 75% of households connected to WPC. On the whole, the rate of connectivity to wastewater pipeline in the study area was 91.56%, however, considering the sensitive nature of wastewater to households and the environment, full (100%) connectivity is the desirable option towards making towns and cities sustainable. To enhance the functional performance of the WWTPs to optimum capacities, factors such as poor maintenance, process malfunction, inadequate number of staff, staff inefficiency, and inadequate funding should be positively addressed considering the benefits of improved city hygiene accruable to households and the environment.*
Keywords: Wastewater Treatment, recycling, City Planning, Abuja.

Introduction

Wastewater management is a critical problem confronting modern cities. Brown (2003) explained that this environmental concern affects sufficient water supply is due to rapid population growth, urbanisation and enormous volumes of wastewater generated. In developing countries, the situation is more desperate as investments focused more on clean water provision than sanitation services (WHO, 2006a). The cost of disposing of $1m^3$ of wastewater is higher than the cost of producing $1m^3$ of potable water in highly populated areas (Gunnerson and French, 1996). It is estimated that the current world population of 7.5 billion has 47% living in cities, with higher annual population growth rate (UNEP, 2010a). According to WHO (2015), about 300 million urban residents have no access to sanitation especially low-income earners that live in slum where there are no hygienic means of disposing excreta and lack adequate means of disposing wastewater. It is a common practice that untreated sewage is discharged into streams or dams or agricultural land. This situation has resulted in the contamination of water resources and has generated great concern to urban planners. Ineffective pollution controls such as nitrogenous emission aggravate the water quality in cities of developing nations (Otterpohl *et al*, 2002). McDonough and Braungart (2013) noticed the contamination of surface water induces algae blooms, fish kill, ecological imbalances and stench the environment. Hence, high levels of nitrate make groundwater unfit for potable water supplies. This affects household access to drinking water by 80%; while the estimated households connected to urban sewage collection systems is estimated at 5% in Latin America and the Caribbean (Looker, 1998). Daniel (2014) recommended from a setback of water and sanitation in American cities, that municipal drinking water is unsafe and unreliable to the

satisfaction of Environmental Protection Agency (EPA) standards. Urban water is not free from *staphylococcus, cryptosporidium* and diseases causing microbes generated from sewerage are discharge into farmlands and water bodies from septic tanks. The diseases generated are within the nitrogen, phosphorus and potassium nutrients caused by human and animal wastes and this affects biomass.

In Africa, 80 million people are at risk of cholera, and 16 million people are at risk of typhoid fever infections per year (WHO, 2011). This results from increased rate of untreated wastewater and poor sanitation as estimated 95% of the generated wastewater is released to the environment (Niemczynowicz, 1997 and 1999). With the growing number of mega cities in Nigeria, the issue of liquid and solid waste disposed into water bodies continues to receive little or no desired attention. Federal Ministry of Water Resources (FMWR, 2000) discovered that many sewage plants do not function effectively as there are many agencies that performed below their statutory management responsibility due to financial deficiency as well as increased urban population. Between 1992 and 1993, Nigeria urban population grew from 5.5% to an astonishing 21%, with about 8.5 million people living below the poverty line of 1$/day (WHO, 2006b). This has retarded the efforts towards improving urban infrastructure, healthcare services, pollution control, as well as effective and efficient water supply and management of municipal waste (sewage and refuse). Leitman (2004) remarked that the expansion in urban population and the increased spatial coverage of domestic water supply has given rise to the need for greater volumes of municipal wastewater recycling. Today migrants moving into the city in high proportion (estimated 28% are low income earners), who find it difficult to pay for water supply (Biu, 2003). Hall (2006) scrutinized the low income earners' inability to access and utilizes wastewater treatment plants in Abuja city, and concludes that this scenario has serious consequences on human health, the environment and economic development. Poor waste water management has the effects of contaminating the water supply sources, thereby increasing the risk of infectious diseases in the overall ecosystems. This implies that access to safe drinking water is constrained, if the indiscriminate discharge of wastewater is not restrained. This improper discharge presents a variety of concerns from providing breeding grounds for communicable diseases to vectors in contributing to air, water and soil pollution (UN-HABITAT, 2003).

This research stems from the rise in urban influx of people causing potential rise in wastewater volume and the discharging of its untreated wastewater. As the urbanisation trend continues to rise, environmental management becomes the most pressing issue in urban governance. Challenges faced by urban planners and managers are to ensure ongoing infrastructural services such as the provision of water and sanitation are planned and sustained (Laugesan *et al,* 2010). The uncontrolled physical development in urban areas has made planning and expansion of water supply scheme and demand vis-à-vis the provision of sewage systems very difficult to meet (OECD, 2012).

Perspectives of Wastewater Management in Nigeria

Until recently, no municipal sewage treatment plants operated in Nigeria. Data from Nigeria Bureau for Statistics (NBS, 2004) shows that the Lagos State sewage treatment plant in Eric Moore, Surulere, receives tanker loads of domestic sewage for discharge directly into the Ebute Metta creek. Many of the drains are unlined, blocked with solid wastes or broken crystal particles. Table 1 shows existing sewage disposal facilities in major cities in Nigeria.

Table 1: Percentage Sewage Disposal Facilities in 4 Selected Major Cities in Nigeria

Facilities	Lagos	Ibadan	Benin	Enugu
Septic tanks	10.0	5.5	8.2	12.0
Pit latrine	55.5	72.2	68.2	61.7
Pail collection	32.5	15.6	10.3	9.3
Others	2.0	7.0	13.3	17.0
Total	**100**	**100**	**100**	**100**

Source: NBS, 2004

Table 1 shows sewage disposal facilities in selected mega cities of Lagos, Ibadan, Benin and Enugu; both in South-West and South-East Nigeria. The Pit Latrine is the most used amongst urban residents of Lagos (55.5%), Ibadan (72.2%), Benin (68.2%) and Enugu (61.7%). Pit Latrine is easy, cheap and

could take short time to construct. The septic tank is a modern and expensive sewage disposal system hence few houses in Lagos (10%), Ibadan (5.5%), Benin (8.2%) and Enugu (12%) could afford it. The inaccessibility of modern sewage system affects the service performance provided by certified septic tanks, pail collections and others with low percentage. Access to excreta disposal considered is enumerated in Table 2.

Table 2: National Access to Means of Excreta Disposal.

Type of wastewater	None	Toilet on water	Flush to water	Flush to septic	Pail or bucket	Covered pit latrine	Uncovered pit latrine	VIP latrine	Others
Total	7.13	4.64	5.38	6.6	4.5	47.32	11.79	1.73	10.9

Source: NBS, 2004

Table 2 shows aggregates of excretal disposal methods in Nigerian cities. The table showed that covered and uncovered latrine had 47.32% and 11.79%, respectively; these constitute the highest generated wastewater within households. Water sewage system which include flush to water (5.38%), flush to septic tank (6.6%) and Very Important Person (VIP) latrine (1.73%) had the least proportion. The open desiccation in open aqua-environment termed "toilet on water" (4.64%) is least because of "no lavatory".

In spite of the increasing rate of urbanisation, many houses still lack toilets. About 43% of urban households as compared to only about 6% of all housing units in the rural areas had toilets; showing that 59% of rural households used pit latrines, about 4% used bucket system while about 29% had no toilets (use hide-out). However, 40% of the urban population used pit latrines, 15% used the bucket system and 4% had no toilets (FMWR, 2000). The industrial database record showed that out of the 534 industries surveyed in Lagos with installed wastewater treatment facilities, 7 were functional. The central wastewater treatment plant in Lagos called *Wemabod*, located in the Ikeja Industrial Estate, accepts wastewater from different industries; some treat it while others discharge it into the sea. A similar treatment plant for 20 industries was constructed in Agbara Industrial Estate, discharges wastewater into Owo River. Wastewater from Iganmu and Apapa Industrial Estates is discharged into the Lagoon, Port Novo and Ebute Metta Creeks, except for the Nigerian Breweries which carries out physical and biological treatment.

Urban Wastewater Treatment Mechanism

By the year 2020, over 5 billion people will live in urban environments and there will be 23 mega-cities with a population of over 10 million each; 18 of which will exist in the developing world (UN-HABITAT, 2003). Central to the urbanisation phenomena are the problems associated with providing municipal services in the water sector, such as the provision of both fresh water and sanitation services. Provision of the services presents major challenges to engineers, urban planners and politicians. It was estimated that 300 million urban residents have no access to sanitation that affected low- income urban dwellers (Forget, 1992). The International Water decade paid insufficient attention to the issue of sanitation and wastewater reuse in the developing world (Alaerts *et al*, 1993), while fresh water systems have been developed for the urban poor, urban drainage and hygiene systems have not been scaled-up; this has led to appalling conditions that threaten the re-emergence of plagues and pestilences in cities (Libralto *et al* 2012). The UNCED Earth Summit with its resultant programme of action referred to as Agenda 21 emphasised the need to tackle urban environmental problems such as pollution. UNEP (2010b) outlined that technological inadequacies have failed to evolve methods of wastewater sanitation. These innovative approaches highlighted new methodologies to public health, recovering resources and protecting water, hence WHO (2015) discovered an integrated approach that involved wastewater zero-discharge and wastewater reuse strategies as the concept being advanced in city municipalities. These include the following:-

Aquatic Macrophytes Treatment: Aquatic macrophytes are used as effective scavengers of wastewater nutrients. In applying aquatic plants in shallow ponds, a combination of secondary and tertiary treatment is commended. It involves symbiotic plants for the purification of wastewater and simultaneous production of plant biomass (Daryl, 2006). These assimilate nutrients into a high quality

biomass that have an economic value. This contrasts symbiotic nature with advanced nitrification and denitrification; where nitrogen is converted into atmospheric nitrogen for further re-use. Studies have harnessed the use of water hyacinth (*Eichhornia crassipes*), pennywort (*Hydrocotyle umbellata),* water lettuce (*Pistia stratiotes)* and duckweed (*Lemnaceae*) for the efficient removal of nutrients. Gijzen (2001) and Daigneau (2012) researched that the potential of plant species for wastewater treatment depends on its efficiency to remove nutrients; its growth has effect on the treatment system, and the possible application of plant biomass. Water hyacinth is used due to its high nutrient uptake capability. The water hyacinth is pumped due to topographic reasons to dislodge ponds. Numerous of these nutrients both small and large are effluents used for irrigation. Bakir (2001) analysed the variants of these options as it allowed for either restricted irrigation or for unrestricted irrigation, i.e. irrigation of crops eaten uncooked.

Anaerobic Treatment System: Edward *et al* (2008) examined treatment in anaerobic system is favourable when energy recovery and cost-effectiveness is accomplished. The organic matter is treated with 3,75l kg of methane as expected for the digestion of Biological Oxygen Demand (BOD). Assuming a substantial conversion is undertaken; it showed a biogases' daily per capita production of 25 to 45l of methane. More so, Bouwer (2000) re-examined the mineralisation of organic matter resulted in less sludge and less carbon dioxide production of methane compared to aerobic treatment. Both methane and carbon dioxide are potent greenhouse gases but the latter is applied for heating in domestic and industrial applications. This effluent reuse includes:

i. Anaerobic filters (e.g. in combination with individual or communal septic tanks);
ii. Up flow, Anaerobic Sludge Blanket (UASB) clarifiers;
iii. Trickling filters; planted, vertical-flow soil filters ("constructed wetlands"); and
iv. Duckweed ponds.

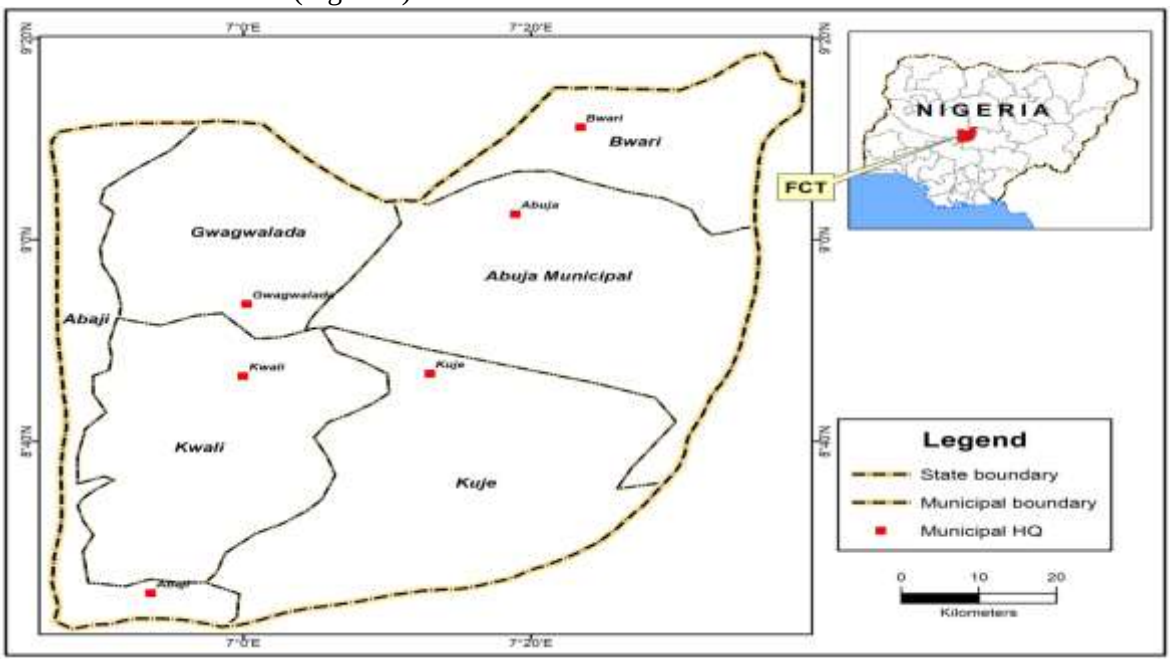
These require moderate construction on how to remove pathogens in stabilised ponds. Otterpohl *et al* (2002) reported on recycling-based system for excreta and grey water, discovered excreta is vacuum-collected from low-flush toilets and treated with organic kitchen residues. The treated and hygenised sludge is used in peri-urban agriculture for soil conditioning and fertilisation. Grey water is treated by vertical-flow constructed wetlands and used for green space irrigation in the infiltration processes. The centralised flush-and-discharge system has high yields and considerable savings of pollutant emissions (organic matter, nutrients) for fertiliser production.

Mechanised Treatment Systems: WHO (2011) observed this system (activated sludge, trickling filter or rotating bio-contactor systems) are efficient (0.5-1m^2/Person Equivalent; PE) as compared to natural treatment systems at 5-10m^2/PE. Veenestra and Alaerts (1996) opine that electro-mechanical wastewater treatment technologies are designed to remove high levels BOD treated effluents. Its removal of pathogens requires chemical inputs to meet disinfection guidelines; this increases the operation cost and complexity of the system. Dependence on chemical disinfection, it also complicates effluent reuse in non-restricted irrigation schemes (Mara and Pearson, 1998). Cairncross and Feacham (1993) discovered mechanised conventional sewerage and wastewater treatment systems require large capital investments, demand high maintenance costs, and are not feasible. Capital intensive and highly mechanized waste disposal solutions utilises indiscriminate collection and disposal. It does not consider the value of recovering organic waste and do not promote "front-end" recycling or neighbourhood (local) reuse of organic waste.

On-Site Treatment Systems: Marsalek *et al* (2001) illustrated that on-site treatment systems have been accomplished through a variety of bucket latrines to cesspits, to composite toilets. On-site pit latrines and soak away pits are not a viable solution for high density urban areas as they depend on the permeability of soil and the infiltration capacity of the local strata (Marsden, 2007). It is composed of variety of cesspits, septic tank and vault toilets are effective in containing wastes, they required frequent servicing depending on the size, to maximised the capacity threshold. The cost to service on-site septic systems is expensive. For that, Strauss *et al,* (1998) confirmed the regular servicing does not occur, and the function of the system becomes inefficient to maintain and service household-level tanks.

The Study Area, Materials and Method

The study area is Abuja, Federal Capital Territory (FCT); the capital city of Nigeria. Abuja is located in sub-Saharan Africa. It becomes the new FCT on 6th February 1976 while the subsequent movement from Lagos to Abuja commenced in 1981. It is an interior virgin landlocked and centralised area that lies between latitude 08^0 25' and 09^0 20' North of the Equator and longitude 06^0 45' and 07^0 39' East of the Greenwich Meridian (Figure 1).



Source: Department of Geography, University of Ibadan.
Figure 1: Map of Federal Capital Territory in Nigeria

Abuja FCT has a land area of approximately 8,000 sq km; however, the city occupies a land area of approximately 250 sq. Km according to Abuja Master Plan. The population is estimated to be more than 1million that resides in the various districts of Abuja Municipal city which includes: Garki, Bwari, Gwarimpa, Asokoro, Maitama, Wuse, Utako, Kado, Wuye, Gaduwa, Kuje and other neighbourhoods. The land uses are mostly residential, administrative, commercial, education and recreational. The city is delineated in accessible enclaves of 17 sectors. These sectors are aligned to the CBD. In every sector are embedded central areas which have services such as: markets, shopping malls, financial institutions, and motor parks, recreational services of parks, gardens, cinema, hotels, playground, etc.; schools, courts, healthcare centres, and worship areas. Good road network augment city efficiency. Functional road network of express characteristics connect each of the sectors, Districts and the CBD. It is this road network that makes Abuja a very effective and accessibility city. However, the rail track is monotonous type with a weak commuter services.

The research used both the primary and secondary sources of data collection. This involves questionnaire administration to households in randomly selected neighbourhoods. Total samples of 320 copies of questionnaire were administered to head of households in CBD, Garki, Maitama, Asokoro and Bwari, within the Abuja city. A total of 64 copies of questionnaire were administered in each of the 5 selected neighbourhoods. These neighbourhoods were selected for this research due to the present of wastewater treatment facilities in them. The questionnaire is structured into sections dealing with the socioeconomic characteristics of households (age, marital status, occupation, income per annum and educational attainment), the nature of wastewater (types whether harmful or harmless), the waste components, mode of transport facilities, and the prominent wastewater generated.

The statutory organisation for wastewater treatment Unit is the Engineering Department of Abuja Environmental Protection Board (AEPB). This unit assisted in the derivation of secondary data. Questionnaire was administered to field workers of the treatment plants to collect data on treatment

plants, the types, capacity usage/threshold, location, functionality (whether regular or seldom), authority operating the plants, the treatment plant influence, by-product effects whether economic, biotic, environmental or technological benefits derived. During the field survey materials used were digital camera, notepad, maps, pens and field assistants to cover the municipal district. Reconnaissance was conducted to enable easy access to data, possible field assistants and location of wastewater treatment plants. A total of 8 field assistants were recruited to ascertain the sewage conditions, capacities and functionalities. The time span for field survey was 24 days. Descriptive statistics were used for data interpretation and analysis.

Results and Discussion

This involves coverage of both household's survey and Wastewater Treatment Plants (WWPs). A total of 320 copies of questionnaire were administered to the five selected neighbourhoods of Abuja CBD, Garki, Maitama, Asokoro and Bwari. This is to ascertain the WWTPs' impact rate on households within the city fringe as seen in Table 3.

Table 3: Wastewater connectivity rate

Neighbourhoods	Connected		Not connected	
	Frequency	%	Frequency	%
Abuja CBD	64	100.0	-	-
Garki	64	100.0	-	-
Maitama	64	100.0	-	-
Asokoro	53	82.81	11	17.19
Bwari	48	75.00	16	25.00
Total	**293**	**91.56**	**27**	**8.44**

Table 3 reveals that all the households in the3 neighbourhoods of Abuja CBD, Garki and Maitama had full connection (100%) to Wastewater Pipeline Circuit (WPC). Asokoro and Bwari neighbourhoods however, had 82.81% and 75% respectively of their households connected to WPC while 17.19% and 25% respectively of the households in Asokoro and Bwari neighbourhoods were not connected to wastewater pipeline circuit in the study area, and thus, implies that while Abuja CBD, Garki and Maitama neighbourhoods had full WPC connection to the city's WWTPs, others had partial connection to WWTPs. On the whole, the rate of connectivity to wastewater pipeline in the study area was 91.56%. This is high, however, considering the sensitive nature of wastewater to households and the environment, full (100%) connectivity is the desirable option towards making towns and cities sustainable. Information on the serviceability rate for WWTP was acquired through respondents' assessment. This enables ascertaining the level of performance as viewed from both the respondents and the WWTP perspective, and is thus, presented in Table 4.

Table 4: There is high serviceable performance rate in WWTP.

	Strongly agree (5)	Agree (4)	Neural (3)	Disagree (2)	Strongly disagree (1)	Total	Mean	Rank
Abuja CBD	42 (210)	8(32)	7(21)	4(8)	3(3)	274	4.28	2nd
Garki	31(155)	12(48)	4(12)	11(22)	6(6)	243	3.80	5th
Maitama	48(240)	9(36)	2(6)	3(6)	2(2)	290	4.53	1st
Asokoro	18(90)	35(140)	3(9)	2(4)	6(6)	249	3.89	3rd
Bwari	12(60)	41(164)	2(6)	5(10)	4(4)	244	3.81	4th

Table 4 shows that the use of 5 points likert scale to assess the rate of serviceability performance of WWTPs placed Maitama neighbourhood in the first position with a mean score of 4.53. this is followed by Abuja CBD as the second position with a mean score of 4.28 and thus implies that Abuja CBD is second most serviceable neighbourhood in terms of WWTPs. Of all the 5 neighbourhoods studied, Garki neighbourhood is the least in terms of serviceable performance rate of WWTPs with a mean score of 3.80.

Table 5: Type of household wastewater discharge

Wastewater Types	Freq	Percent
Sewerage	163	50.9
Food Remnants	104	32.5
Waste canned food	48	15.0
others	5	01.6
Total	320	100.0

In terms of types of household waste water discharge, Table 5 reveals that sewerage discharges have the highest percentage of 51 in the 5 neighbourhoods of Abuja FCT. Food remnants/dregs discharge

came second with 32 percentage contributions to household waste water discharge in the study area. The waste generated from domestic clean-up of rooms, clothing and car washing activities contributed about 2 percent to total household waste water discharge in the study area, and thus, constitute the least contributory factor household waste water discharge in FCT. Package waste food involves canned and fast food discharges. This indicates a contribution of 15% and thus, has substantial impact on total discharge due to city liveability and industrial food processing. The benefits derived by residents from the various by-products of WWTPs were investigated to ascertain the extent of the fall-back services rendered in waste water reuse as seen in Table 6.

Table 6: Types of benefit derived by residents

s/n	Benefits	Freq	Percent
1	Water recycling	202	63.12
2	Animal product	63	19.69
3	Farm input	34	10.63
4	Others (Specify)	21	6.56
	Total	**320**	**100**

In terms of benefits derived from WWTPs by residents, Table 6 shows that water recycling in WWTP within the selected 5 neighbourhood has the highest percent (63.12%). This implies that the use of recycled water is in high percentage among households for various domestic uses such as cooking, washing, bathing and drinking. The Wastewater is recycled for the extraction of animal feeds for birds, cat and dog and this has 19.69%. Another benefit derived from WWTPs is production of farm input such as carbon, potassium, phosphorus and nitrates nutrients and this accounted for about 11%. This shows that the by-products of waste water recycling have different types of benefits that accrue to the households and have to be safe and reliable, hence the need to assess the quality assurance performance amongst household. This was assessed and graded as poor, fair, good and very good as seen in Table 7.

Table 7: Quality assurance performance

Performance	Freq	%
poor	28	8.7
Fair	216	67.5
Good	56	17.5
Very Good	20	6.3

Table 7 shows the assessment of quality assurance performance of WWTPs in terms of their impact in the neighbourhoods. On the whole the assessment shows a fair performance of about 68%. This implies that this level of performance is weak and therefore demands that the Engineering Department and the WWTPs should improve on serviceability to make Abuja city modern and waste recycled inclined.

Status of Wastewater Treatment Plants (WWTPs)

There are 15 sewage treatments plants in Abuja municipality, amongst these are 14 aerators. The treatment system is capable of handling about 900,000 litres of wastewater generated per day (Population Equivalent). The operation of these treatment plants are constrained by factors such as poor maintenance, process malfunction, inadequate number of staff, staff inefficiency, and inadequate funding which collectively limited the operational capacity of the plants. The 13 existing aerators in the city have either been discontinued or are malfunctioned. The sewage collected is discharged into the surroundings water bodies untreated. It is a common sight at these treatment plants to see raw sewage gushing out of the sewage holding chamber. The Table 8 shows the location, usability, installed capacity, operational capacity and usage capacity of the 15 plants.

Table 8: Status of Wastewater Treatment Plants in Abuja

S/n	Location	Usability	Installed Capacity, (Litres per day) (000)	Operational Capacity (Litres per day)	Usage Capacity (%)
1	Wupa	Functional	700	210,000	30
2	Utako	Not functional	100	0	0
3	Wuye lagoon	Functional	50	20,000	40
4	Mogadishu	Not functional	10	0	0
5	Mambilla barrack	Functional	10	0	0
6	Gudu	Functional	10	0	0
7	Life camp	Functional	3	0	0
8	Asokoro suburb	Functional	3	0	0

9	Asokoro ministerial	Functional	2	0	0
10	Mabushi ministerial	Functional	2	0	0
11	Maitama	Functional	2	0	0
12	Ainah (NIA)	Functional	2	0	0
13	Gulf course	Functional	2	0	0
14	Niger cantonment	Functional	2	0	0
15	Presidential villa	Functional	2	0	0
		Total	**900,000**	**230,000**	**25.56%**

Table 8 shows the status of all the 15 WWTPs in terms of their functionality. Table 8 shows that only 2 treatment plants (Utako and Mogadishu) were not functional; all the other 13 WWTPs were functional. The Asokoro Ministerial aerator passed as an open sewer. The Wupa treatment is the main treatment plant and has a capacity of 700,000 litres per day (Population Equivalent (PE)). It is currently operating at 30% capacity which translates to about 210,000 litres per day. The plant is in its excellent operational state, but receives very low volume of sewage due to the few number of sewer lines connected to it. The Wuye Lagoon has a capacity of 50,000litres per day (PE) but operates at 40% installed capacity; that is 20,000 litres per day (PE).

Abuja city's population was 778,567 (NPC, 2007), analysis of the situation shows that only 29.54% proportion of wastewater generated is treated. The proportion of 70.46% is discharged as untreated into surrounding water bodies. Although approximately 80% of the households are connected to the central sewage system, very little work is done to ensure that the existing treatment plants are effectively operational. The Abuja Environmental Protection Agency (AEPA) is in-charge of wastewater management and is under-funded, hence carrying out its statutory roles become difficult. FMWR (2000) realised that without permit, illegal connection to the sewer system were made and this resulted in the connection of gray wastewater (storm water) pipes into the domestic sewage system. The entire system experienced smeared inadequacies that culminated to inefficiencies in the overall management of wastewater infrastructure.

The AEPB is responsible for monitoring and administering the construction, operation and maintenance of sewer lines. The running of the aerators is controlled by the Federal Capital Development Authority (FCDA), except the Wupa treatment plant that was managed by Shand Construction Company (SCC) under a management contract that ended in March 2009. New arrangements were made for wastewater management by creating the Liquid Waste Department (LWD) of the AEPA and the Water and Sewage Department (WSD) of the FCDA to oversee some particular aspects of wastewater management. The existing situation where of Departments of multiple institutions are in charge of waste water management aspects is responsible for the gross inadequacy experienced in the sector. This arrangement does not guarantee proper coordination, as there are administrative overlap and policy contradictions. Wastewater management is a serious issue that has gone beyond ad-hoc planning approach.

Wastewater Treatment and recycling

Urban wastewater collection is based on the conventional sewer (central sewage) system that depends on gravity to convey to the various treatment plants. This means that collection pipes slope downward towards the treatment plant. Wastewater is not separated before it enters the collection pipes. Sewage is collected through the underground tertiary lines from houses to district collector sewers, then to the trunk sewer (interceptors) lines located at the lowest parts of the neighbourhoods to the different treatment plants. These are situated at separate sewage drainage basins. The tertiary and district collector pipes are of polyvinyl chloride (PVC) materials ranging between 100-300mm diameters (Lawrence *et al*, 2001 and OECD; 2012, 2013). Grey wastewater is collected through a separate network of buried pipes and was discharged into the environment.

To ensure the pipes do not clog with solid material, the down slopes of the pipes is maintained at a steady gradient standardised throughout the system. Edwards *et al* (2008) traced that pipes are laid in straight alignments between the manholes to ensure blockage does not occur as it is accessed. The findings from the study show that about 90% of households in the study area are connected to the

network of both tertiary and secondary sewer lines. Sewage generated is conveyed to mini treatment plants. There are 6 major sewage drainage basins separated by mountain ranges. These do not linked areas of Maitama and Asokoro neighbourhoods' extension to the central system as serviced by a particular on-site disposal system. The commonest used on-site system is the septic tank; and this requires periodic evacuation when the system is filled up. The city's wastewater treatment is through the activated sludge treatment process as organic matter is partly degraded and transformed into sludge. This treated sludge is preceded by primary treatment in the removal of grit, screening and primary debris.

Treatment stages

There are 15 WWTPs made up of 14 mini-sewage plants (aerators) and the main sewage treatment plant located at Wupa. These wastewater treatment facilities treat both human and industrial waste generated by residents of the municipality. The 14 aerators handled wastewater for a PE of between 2,000-100,000 inhabitants. The Wupa basin wastewater treatment is designed to treat wastewater flow for 700,000 PE with possible extension to additional 100,000PE. To ensure that pipes were not clogged with solid material, the down slopes are maintained at a steady gradient that is standardised throughout the system. The pipes are laid at a gradient of $< 75^0$manholes. As the water reaches the plant, it goes through 2-3 stages of treatment as:

i. The primary stage involves the treatment that functions within septic tank. It allows the solid particle to settle and the scum to rise. The treatment screen pools or ponds to utilize at treated biotic treatment plant.
ii. The secondary stage removes that organic materials and nutrients through the activities of bacteria. The water flows to large aerators and bacteria are consumed in the sewerages. The wastewater then flows to a settling tank where the bacteria are not in used. The secondary treatment removes 90% of solid and organic material from wastewater and terminates at the stage of the aeration.
iii. The third stage tagged *"the aeration"* is carried-out by Wupa wastewater treatment plant. It allows the effluent substances to process through the ultraviolet light. Bacteria are killed for the second time through the ultraviolet light before discharged into the Wupa River. The treatment plant receives and treats $210m^3$wastewater per day which is an estimated 30% installed utilization capacity.

The institutional wastewater treatment is the statutory role of Liquid Waste Department (LWD) unit of the AEPA. It discharges, monitors, recycles and undertakes the construction of sewer lines, while the operation of the aerators is carried out by the Water and Sewage Department (WSD) of the FCDA. Under the structure, AEPA and FCDA managements function as non-profitable public corporation endorsed with the wastewater treatment and recycling functionalities that affect urban welfare and goodwill service satisfaction to the residents.

Conclusion and Recommendations

The discharge of waste water generates strong repulsive acidic stench which is injurious to human and the environment. The treated sludge should be used as farm inputs to improve soil conditions and create opportunity for reuse of the treated potable water for household consumption. Wastewater treatment should sanitise the environment; augment ultimate environmental harmony to suit human habitation. Of the 15 waste water treatment plants, only 2 were functional at 40% and 30% capacities. This implies a rather weak performance and does not portends sustainable approach, hence a concern to Planners, Environmentalists, Ecologists and Municipal Administrators. To enhance the functional performance of the WWTPs to optimum capacities, factors such as poor maintenance, process malfunction, inadequate number of staff, staff inefficiency, and inadequate funding should be positively addressed considering the benefits of improved city hygiene accruable to households and the environment.

References

Alaerts, G. J., Veenestra, S., Bentvelsen, M. and Van Duijl, L. A. (1993) Feasibility of Anaerobic Sewage Treatment in Sanitation Strategies in Developing Countries, *Water, Science & Technology*, 27 (1):179-186.

Bakir, H. A. (2001) Sustainable Wastewater Management for Small Communities in the Middle East and North Africa. *Journal of Environmental Management* 61: 319–328

Bouwer, H. (2000) *Water Management: Emerging Issues and Challenges*, accessed 17th April, 2015 https://books.google.com.ng/books?isbn

Brown, B. (2003) *Institutionalization of Integrated Urban Storm Water Management: Multiple-Case Analysis of Local Management Reforms Across Metropolitan Sydney*, PhD Thesis, University of New South Wales, Sydney. NS Wales.

Biu, I. (2003) *Making Abuja Works*. Daily Trust Newspaper. Thursday, 28th August.

Cairncross, S. and Feacham, R. (1993) *Environmental Health Engineering In the Tropics*, Chichester: Wiley.

Daigneau, E. (2012) Curbside composting added to a major city: is it your? Governing. Febuary. http://www.governing.com/topics/energy-env/gov-curbside-composting-added-to-major-city.html

Daniel, T. 2014. *The Environmental Planning Hanbook for sustainable communities and regions.* Chicasgo; American Planning Association, Planner Press. 141-220

Daryl, S. (2006), *Growing Crops with Reclaimed Wastewater*, accessed 19th December, 2016. https//books.google.com.ng/books?isbn=0643099034

Edwards AC, Kay D, McDonald AT, Francis C, Watkins J, Wilkinson JR and Wyer MD (2008) Farmyards, An Overlooked Source for Highly Contaminated Runoff, *Journal of Environmental Management* 87, 551-559

FMWR (2000) *Federal Ministry of Water Resources, Nigeria, Annual Report*, year 2000

Forget, G. (1992), *Health and the Environment: A People-Centered Strategy*, Ottawa: International Development and Research Centre.

Gijzen, H. J. (2001) *Low Cost Wastewater Treatment and Potential for Reuse: A Cleaner Production Approach to Wastewater Management*, Paper Presented at the International Symposium on Low-Cost Wastewater Treatment and Re-use, NVAWUR-EU-IHE, February 3-4, 2001, Cairo, Egypt.

Gunnerson, C.G. and French, J.A. (1996) *Wastewater Management for Coastal Cities: The Ocean Disposal Option*, Environmental Engineering Series. Springer-Verlag Berlin/Heildelberg: 345-89.

Hall, D. (2006) *Water and Electricity in Nigeria*. www.world-psl.org

Laugesen, C. H., Fryd, O., Koottatep, T.and Brix, H. (2010) *Sustainable Wastewater Management in Developing Countries: New Paradigms and Case Studies from the Field*, ASCE Press, Virginia, USA

Leitman, J. (2004) *Rapid Urban Environmental Assessment: Lessons from Cities in the Developing World*, Vol. I: Methodology and Preliminary Findings (Urban Management program Discussion Paper; 14. Washington, DC: WB

Libralto, G.; Ghirardini, A.V. and Avezzu, F. (2012) To Centralise or to Decentralise: An Overview of the Most Recent Trends in Wastewater Treatment Management. *Journal of Environmental Management* 94, 61-68

Looker, N. (1998)*"Municipal Wastewater Management in Latin America and the Caribbean"*, R.J. Burnside International Limited, Municipal Water for the Canadian Environment Industry Association, 1998

Mara, D. and Pearson, H. (1998) *Design Manual for Waste Stabilization Ponds in Mediterranean Countries*, European Investment Bank, Leeds, England: Lagoon Technology International Ltd

Marsalek, J., Q. Rochfort, and D. Savic, (2001) Urban Water as a Part of Integrated Catchment Management, Pages 37–83 In C. Maksimovic and J. A. Tejada-Guilbert (ed.), *Frontiers in urban Water Management: Deadlock or Hope*. IWA Publishing, Cornwall.

Marsden Jacob Associates (2007) *The Economics of Rain Water Tanks and Alternative Water Supply Options*, A report prepared for Nature Conservation Council of NSW, Australian Conservation Foundation and Environment Victoria.

McDonough, N. and Braungart, M. (2013) *The Upcycle: beyond sustainability designing for abundance*. New York, North Point Press. 8-36

National Bureau of Statistics; NBS (2004) *National Bulletin; Nigeria economy*, Abuja.

Niemczynowicz, J. (1997) The Water Profession and Agenda 21, *Water Quality International*, March/April: 9-11

Niemczynowicz, J. (1999) Urban Hydrology and Water Management: Present and Future Challenges, *Urban Water*, 1 (1): 1-14, March

OECD (2012) *Water Quality and Agriculture – Meeting the Policy Challenge*, OECD Studies on Water, OECD Publishing

Otterpohl, R., Braun, U. And Oldenburg,M. (2002) *Innovative Technologies for Decentralised Wastewater Management In Urban and Peri-Urban Areas*, 5th Specialised Conference on Small Water and Wastewater Treatment Systems Istanbul-Turkey, 24-26 September 2002

Strauss, M., Heinss, U. and Montangero, A. (1998) *Issues in Faecal Sludge Management And Project Review*. Swiss Federation Institute for Environmental Science and Technology (EAWAG), Water and Sanitation in Developing Countries (SANDEC) and Asian Institute of Technology (AIT)

The Abuja Master Plan (1978) Federal Capital Territory. IPA

UN-HABITAT (2003) *Water and Sanitation in the World's Cities*, United Nations Human Settlements Programme, Earthscan, London

UNEP (2010a) *Clearing the Waters, a focus on Water Quality Solutions*, United Nations Environment Programme, United Nations Environment Programme;

UNEP (2010b) *Africa Water Atlas, Division of Early Warming and Assessment (DEWA)*, Kenya: UNEP

Veenestra, S. and Alaerts, G. (1996) Technology Selection For Pollution Control, In A. Balkema, H. Aalbers And E. Heijndermans (Eds.), *Workshop On Sustainable Municipal Waste Water Treatment Systems:* Leusdan, the Netherlands. ETC in Co-Operation with WASTE, 12-14 November, 1996: 17-40.

World Health Organisation (2006a) *Guidelines for the Safe use of Wastewater, Excreta and Grey* Water Volume 2: Wastewater use in Agriculture, WHO Geneva 221 pages

WHO (2011) *Guidelines for drinking-water quality*, 4th ed. World Health Organisation, Geneva.

WHO (2015) *Sanitation Safety Planning: manual for safe use and disposal of wastewater, greywater and excreta*. Geneva: World Health Organisation.
http://apps.who.int/iris/bitstream/10665/171753/1/9789241549240eng–

ASSESSMENT OF FLOOD VULNERABILITY IN A SECTION OF AKWA IBOM STATE USING GEOSPATIAL TECHNIQUES

Aniekan Eyoh, Inemesit Ettang, Okon Ubom, Akwaowo Ekpa, Eno-obong Ukpo
Department of Geoinformatics & Surveying, Faculty of Environmental Studies, University of Uyo, Uyo, Nigeria.
Corresponding Author's Email: aniekaneyoh@uniuyo.edu.ng , +2348064733566

ABSTRACT
This study used GIS and remote sensing to identify flood vulnerable areas within Uyo and Itu Local Government Areas so as to produce an understandable GIS based flood risks map of the area. Application of GIS and remote sensing technology to map flood areas makes it easy to plan measures which reduce the flood damages and risks involved. The bio-physical and socio-economic factors used for evaluation of environmental suitability of the resettlement site were rainfall, soil, land use/land cover, slope, elevation, flow accumulation and flow direction. Land use/land cover information was extracted from Landsat OLI images of 2021; rainfall information was extracted from NIMET dataset of Akwa Ibom state while road networks and towns were extracted from the Open-source administrative map. By analyzing the information extracted, weights were assigned to the information based on their suitability for human settlement. Weighted overlay techniques were then applied to derive a flood vulnerability map. Five flood vulnerable area maps were produced identifying five category risk zones; high, vulnerable, moderate, less and non-vulnerable zones. The analysis of this factor indicated that 7% of the study area was non-Vulnerable, 43% was Less Vulnerable, 45% was Moderately Vulnerable, 5% was Vulnerable and 0% of the area was highly Vulnerable. For Land use/land cover; 31% of the study area was forested, while 40% represented built-up, water body accounted for 0%, farm land 9% and bare land accounted for 1% and Shrub accounted for 19%. The result of this research will serve as a reliable and ready information source for a sustainable flood mitigation measure within the study area.
Keywords: *Flood, Vulnerability mapping, NASADEM, OLI*

INTRODUCTION

The world has experienced an increasing impact of disaster in the past decade. Many regions are exposed to natural hazards with unique characteristics. In Tropical Africa, one of the most common hazards is flooding, due to the severe impact of climate change. Flooding is a generally a temporary condition of partial or complete inundation of normally dry areas from overflow of inland or tidal waters or from unusual and rapid accumulation of runoff (Jeb and Aggarwal, 2008). According to European Commission (2007), a flood can be defined as a natural phenomenon that results in the temporary submerging with water of a land that does not occur under normal conditions. Floods can be caused by anthropogenic activities and human interventions in the natural processes such as increase in settlement areas, population growth and economic assets over low lying plains prone to flooding leading to iterations in the natural drainage and river basin patterns, deforestation and climate change (EC, 2007). They are naturally occurring; they cannot be prevented and have the potential to lead to fatal causes such as displacement of people and damage to the environment (Adeoye *et al*., 2009).

In the work of Essien *et al* (2018), the researchers indicated that past floods in Akwa Ibom State have claimed thousands of lives and rendered hundreds homeless and destroyed infrastructures within Akwa Ibom State. Flood vulnerability maps need therefore to be created as they provide a basis for the development of flood risk management plans. What is more, these plans needed to be effectively communicated to various target groups (including decision makers, emergency response units and the public) as a measure to reduce flood risk by integrating different interests, potential and conflicts over space and land use in a city.

African nations have been badly affected by floods. Media and aid organizations have reported a lot of flooding incidences in Sub-Saharan Africa which resulted from several days of rainfall. In Nigeria, aside from droughts, floods cause almost 90 % of damages resulting from natural hazards (Adeoye *et al*., 2009). In Benin, floods have severely affected the lives of over 600,000 people and rendered hundreds of thousands of people homeless (African Research Bulletin, 2010). In the northern parts of the country, entire villages and huge sparse of agricultural land have been destroyed by flooding (African Research Bulletin, 2010). In recent times, floods have destroyed property worth millions of naira in the different areas of Nigeria. Flooding in urban areas is seriously becoming an ecological

menace in Nigeria as several coastal areas along the Atlantic Ocean, surrounding cities and river valleys are affected by flooding on a yearly basis (Jeb and Aggarwal, 2008). Indeed, floods have caused land degradation in some other parts of the country. Majority of floods are harmful to human settlements and yearly flooding on average victimizes 20,000 lives and affects 75 million people (Coburn, 1994). The obvious reason for flooding especially in municipalities and coastal areas in Nigeria lies in the wide distribution of low-lying coastal areas and river floodplains, and because these areas have fast become a long-standing attraction for human settlement.

There are many aspects of assessing flooding such as the use of Ground survey data, Photogrammetry, Remote Sensing and Geographic Information System. The advancement and innovations in GIS/Remote sensing has offered a new dimension, and has become an effective approach to mapping flood vulnerability. The main advantage of using GIS and Remote Sensing is the availability of high resolution, consistent and repetitive coverage of events and the environment, and capability of measurements of earth surface conditions and that it does not only generate visualization for flooding but also creates a potential to further analyze these events to estimate the probable damage due to flood and it provides a synoptic and comprehensive view which is not possible through ground surveys.

The problem of flooding in Uyo and Itu LGA is increasing, and yearly the number of people affected is quite alarming. Floods incidents in Uyo and Itu LGA urban happen in varying locations and at varying magnitudes giving them different effects on the environment. In Akwa Ibom State, flood occurred in 2020 which destroyed 100 houses and displaced 300 persons in Eket Local Government Area (NAN, 2020). Currently, in Nsukara Offot, Mbiabong Etoi, Nelson Mandela, Urua Ekpa, Ikpa road, Idak Okpo and environs, there have been severe cases of flood which has hindered vehicular movements and caused damages to houses, farmlands and settlements. There is no adequate information for the government to base their decision on the rate of flood, which will guide them in adopting sustainable measures toward the control of flood menace. Hence, this research is set out to carry out flood risk assessment in Uyo and Itu LGA, Akwa Ibom State using geospatial technique. This was achieved through the following objectives; acquiring Global Elevation Data for the study area, determination of terrain parameters, generation of land use/land cover map of the study area using supervised image classification, multi-Criteria assessment of the situation using environmental factors and calculation of percentage of flood vulnerability in the study area.

STUDY AREA

Uyo is a L.G.A in Akwa Ibom State and the state capital lying at latitudes 5°02`N, and longitudes 7°55`E (Fig 1.). It is bordered on the East by Uruan L.G.A., on the west by Abak and Abia State, on the south by Ikono, Ibiono Ibom and Itu L.G.A and on the South by Ibesikpo, Nsit Ibom and Etinan L.G.A. Uyo is made up of approximately 440,000 inhabitants (2006 Census). In addition to English, the main spoken language is Ibibio. The elevation of Uyo is about 196m above sea level. The relief of Uyo consists of moderate undulating and low-lying rolling topography. The sand are mainly poor consolidated sandy soils.

Itu is a Local Government in Akwa Ibom State which lies at latitude 5°10’N and longitude 7°59’S and is located in the southeast of Nigeria and. It occupies a land mass of approximately 606.10 square kilometres. It is bounded in the North and Sout-East by Odukpani in Cross River State and Arochukwu in Abia State, in the West by Ibiono Ibom and Ikono Local Government Areas, in the South and South-East by Uyo and Uruan Local Government Areas, respectively. Farming and fishing are the major occupation of the people of Itu L.G.A. It lies within a coastal area where the major Ikpa River passes through and it is within the Ikpa River Basin which is a major tributary of the Cross River Basin.

The study area (Uyo and Itu LGA) is highly populated area in Akwa Ibom hosting many residences, business outfits, markets and numerous educational institutions (both private and public) including the University of Uyo town campus. The major road in the area (Itu) is the main road leading to Cross River State.

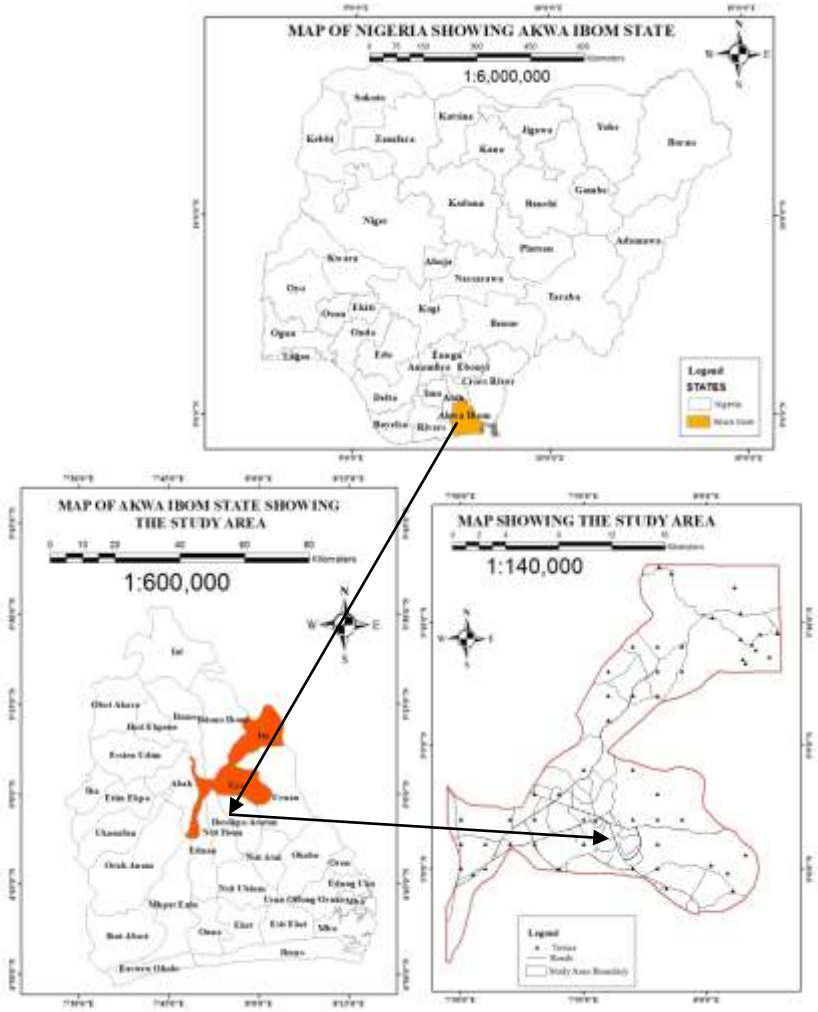


Fig .1: **Map Showing Study Area**

CLIMATE AND WEATHER CONDITION OF STUDY AREA

According to Koppen climate classification, Akwa-Ibom State has a Tropical Monsoon climate (AM) with mean annual temperature of 26.5˚C and average annual rainfall of 2600mm. It experiences two distinct seasons; Wet and Dry, with the Wet occupying a longer duration. The Dry season often begins with the onset of tropical continental air mass often referred to as "Harmattan" predominantly occurring between the months of November and February. The lowest amount of rainfall often occurs in December and highest in July. The climate is typically that of the humid tropics with rainfall in all months of the year. Humidity is high (>80%) and cloud cover is prevalent, especially during the rainy season (Ekpoh, 2015).

MATERIALS AND METHODS

This section gives a detailed framework and methods that was involved in the production of a flood vulnerability map of the study area. The flowchart in fig. 2 shows the methodology steps that were employed for the execution of this research.

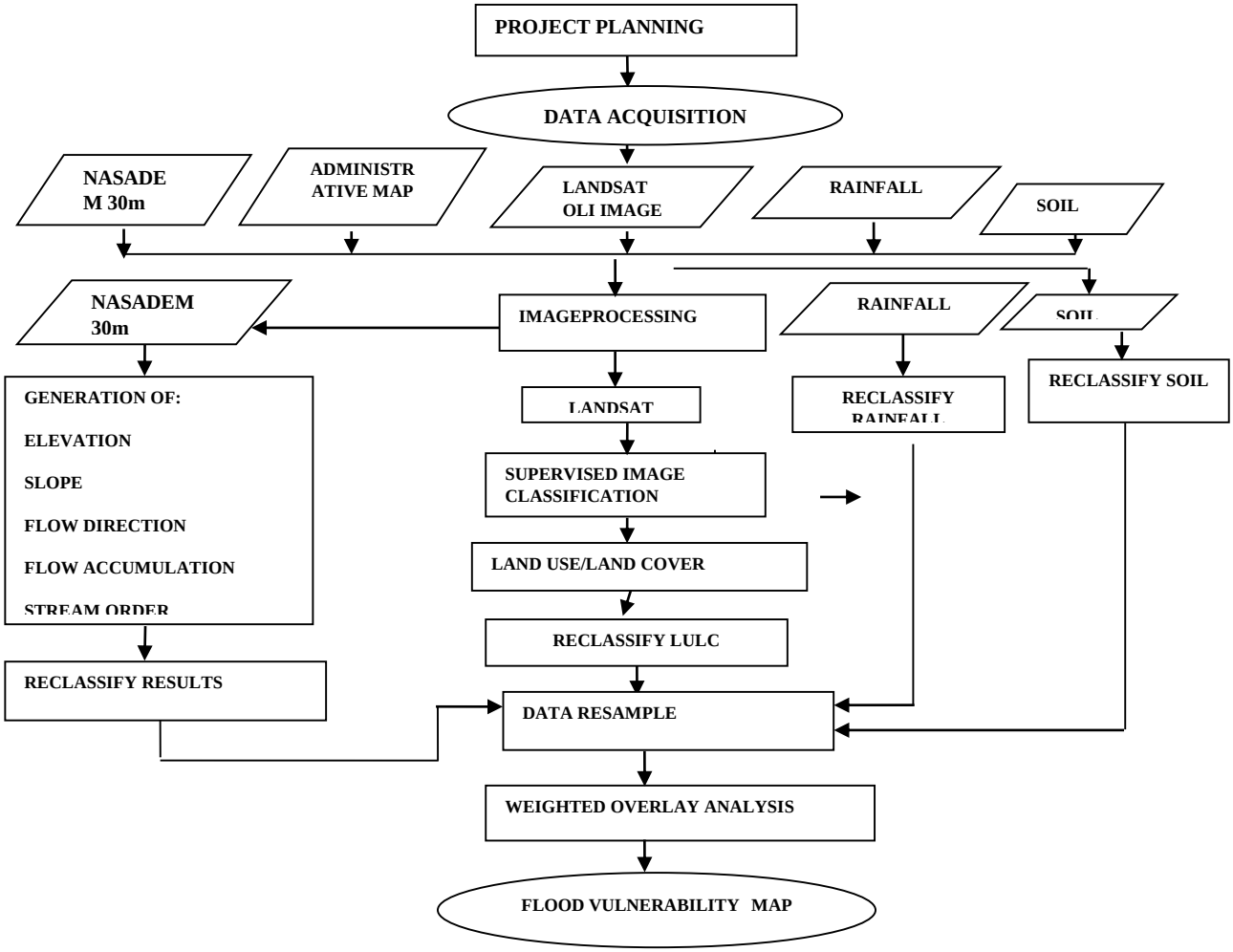


Fig. 2 **Flowchart of Methodology**

DATA USED

Table 1 **Data, Data Type and Data Sources**

Data	Data Source	Data	Year
GPS Coordinates	Field Work	Primary	2021
Pictures	Field Work	Primary	2021
NASA DEM (30m)	NASA Website	Secondary	2020
LANDSAT 8	USGS Website	Secondary	2020
Water Body / River	ASTAL	Secondary	2020
Akwa Ibom State Map	ASTAL	Secondary	2020
Soil Data	ASTAL	Secondary	2020
Rainfall Data	NIMET	Secondary	2007 - 2018

DATA SOURCE AND DATA ACQUISITION

The primary data comprised all data obtained directly from field; in this case, the field acquired coordinates of flooded points within the study area. The instrument used for primary field data acquisition was the hand-held GPS receiver (Garmin GPSMAP 78sc). The secondary data which were

acquired to aid in the successful execution of the research were the global elevation datasets (NASA 30m DEM) and LANDSAT OLI image of 2021.

DATA PROCESSING

The projection tool in the Data management tool set present in ArcGIS was used to project the Global elevation datasets from WGS 84 geographic coordinates (Geocentric) to UTM zone 32 Cartesian coordinate system. The different bands in the Landsat images were composited in ArcGIS using the color Infrared (5, 4, 3) band combination. The Data Management Tool "Clip" was applied from the raster processing box to create the elevation model from the administrative map of the state which was obtained from Advanced Space Technology Application Laboratory. The geometry of the administrative map was used to define the extent of the output raster. Each of the composite images were clipped to the extent of the study area.

Maximum Likelihood analysis of supervised classification was performed on the Landsat images as some of the features of the study area were known. The images were classified by grouping/clustering cells with the similar reflectance values. These land use land cover classes were derived from Landsat 8 imagery for the study areas. Five land use classes (Built up area, Farm Land/Bare Land, Forest, Water body and Shrub) were identified. The built-up area accounted, for 40% of total area, Forest accounted for 31%, water body accounted for 0%, farm land 9% and bare land accounted for 1% and Shrub accounted for 19%.

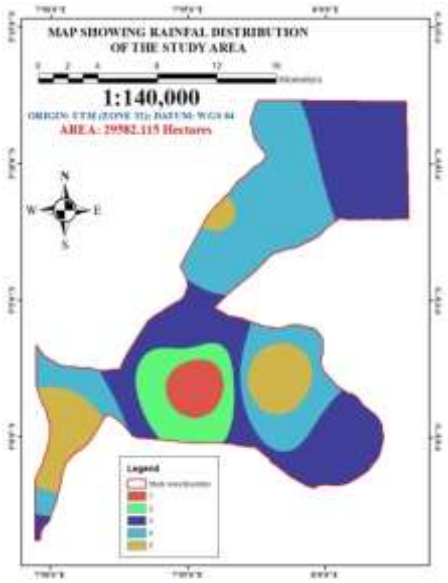
The SRTM 30m DEM sinks was filled using the 'Fill' tool in Arc Tool box. A depression less DEM was used to generate a flow direction raster. Flow accumulation was carried out using the hydrology tool under the spatial analyst tool of the arc tool box in ArcMap, the flow direction served as the input. Stream Order assigns a numeric order to segments of a raster representing branches of a linear network. This tool was used to identify the different sizes of river to be able to articulate the flow direction of each river channel. The slope map was derived from a DEM data covering the study area. The slope ranges between 0 and 28.7963degrees with a mean slope of 4.79 degrees. Flooding occurs most commonly from heavy rainfall when natural watercourses do not have the capacity to carry excess water, according to the flood record by NIMET, this case often occurs in Akwa Ibom State. Soil erodibility was used as a flood prediction parameter because of its influence on runoff.

RESULTS AND DISCUSSIONS

RECLASSIFICATION

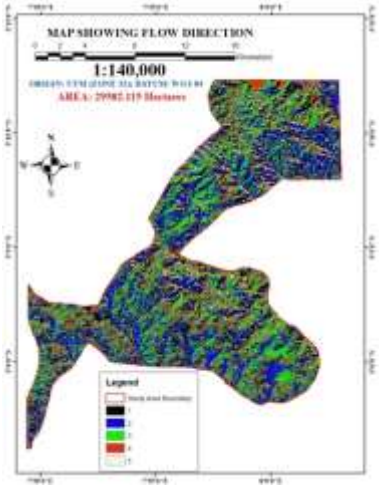
The reclassification was done using the natural breaks grading method in ArcMap platform. The class with the least flood susceptibility or influence in flood initiation was assigned a value of 1; the next level of flood risk induction was assigned 2, and so on (Blistanova et. al., 2016). According to the intensity of importance, the five contributing factors to flood which include rainfall, slope, soil, land use/land cover, and flow direction were all reclassified. After classifying each factor to properly symbolize the scenario, they were further reclassified to enable further analyses. The reclassified maps as shown below are based on the intensity of importance from the weighted overlay used as an input data to compute the vulnerability map of the study area.

The ranking is user defined, supported by literatures and also depending on their significance or influence on flood risk. The ranks were further grouped into a rating index of high and low risk groups.



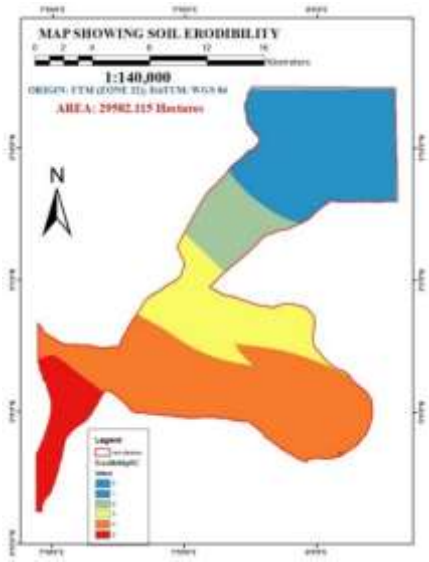
Rainfall was reclassified into 5 categories as shown on Fig. 3, from the least rain intensity reclassed as 1 to the highest rain intensity as 5.

Fig. 3 **Reclassified Rainfall Map**



The output of the Flow Direction tool is an integer raster whose values range from 1 to 255. The values for each direction from the center are:
For example, if the direction of steepest drop was to the left of the current processing cell, its flow direction would be coded as 16. Flow direction was reclassified into five classes so as to be used for the overlay analysis.

Fig. 4 **Reclassified Flow Direction Map**

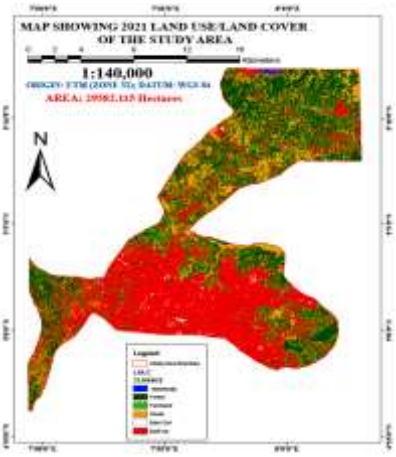


Also, soil types were reclassified into only 5 classes (Fig. 5). Class 1 that does not encourage flooding and class 5 that makes flooding possible.

Fig. 5 **Reclassified Soil Map**

Five land use classes (Built up area, Farm Land/Bare Land, Forest, Water body and Shrub) were identified. The built up area accounted, for 40% of total area, Forest accounted for 31%, water body accounted for 0%, farm land 9% and bare land accounted for 1% and Shrub accounted for 19%. Bare soils are areas which were mainly plain ground with no specific use or development. From the chart, it covered a total of 2.314km^2, built up area covered 119.6199km^2, Farmland covered 27.2736km^2, Forest covered 91.9071km^2, Water body covered 0.5607km^2 and Shrub covered 53.713km^2.

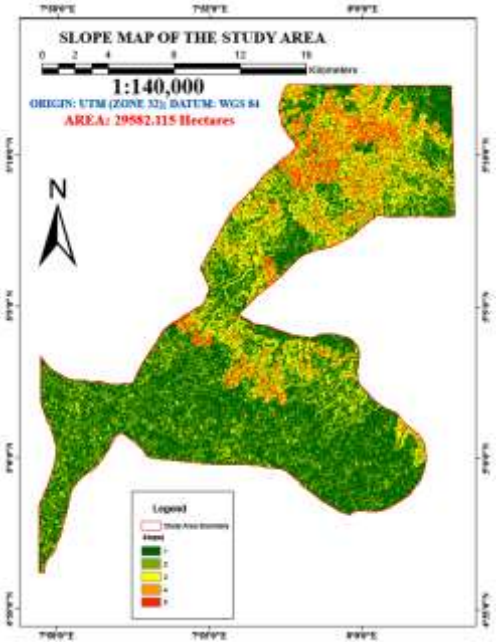
Table 2: LULC Distribution of the Study Area



LAND COVER TYPES	AREA COVERED (Km^2	PERCENTAGE (%)
Built-Up Areas	119.6199	40
Forest	91.9071	31
Waterbody	0.5607	0
Farmland	27.2736	9
Bareland	2.314	1
Shrubs	53.713	18

Fig. 6 **Reclassified LULC Map**

The parameters of land use and soil types were classified similarly to previous studies with modifications according to the characteristics unique to the area of study. The land use was reclassified into 5. The Value 1 for the dense forest which is least susceptible, 2 for shrubs, 3 for farmlands, 4 for waterbody and 5 for the most susceptible (built up areas/bare lands) (Table 3).



Likewise, the slope classes were initially 5 groups, from the least percent to the highest. The slope was then reclassified into 5 groups (Fig. 6) with 1 representing the steepest slope (13.495-28.796 percent) and 5 for the less steep slope gradient (0-2.568 percent) which is more susceptible to flood risk (Table 2). This classification follows from (Samanta et al., 2016) who considered slope gradients less than 10 percent as most susceptible while Orok (2011) espoused slopes less than 1.3 percent as most vulnerable.

Fig. 7 **Reclassified Slope Map**

MULTICRITERIA APPROACH (WEIGHTED OVERLAY OPERATION)

Weighted overlay operation overlays several raster using a common measurement scale and weights each according to its importance. In this research five contributing factors were examined. These include rainfall, slope, elevation, land use land cover, and flow direction. The impact of each of the above contributing factors was examined by introducing them one after the other in the model. The result shows a very close representation of the reality. The contributing percentages for the factors are Mean Annual Rainfall (25%), Slope (20%), Land use (25%), Elevation (15%), and flow direction (15%). Despite the fact that Mean Annual Rainfall (MAR) has the same percentage weight alongside with land use and slope, the analysis reveals that the MAR contributed more to flooding than other factors considered in the model followed by slope, drainage and land use. These factors were reclassified to obtain values for each layer which was used in the weighted overlay model.

Table 3 Weighted flood hazard ranking

Parameters	**Relative Weight (%)**	**Reclassed Parameter**	**Ranking**	Definition
Rainfall	20	260.59 - 329.58mm 243.48 - 260.58mm 239.23 - 243.47mm 222.11 - 239.22mm 153.1 - 222.1mm	5 4 3 2 1	Highly Vulnerable Vulnerable moderately Vulnerable Less Vulnerable Non Vulnerable
Slope	20	13.322 - 32.177 8.330 - 13.322 4.847 - 8.330 2.394 - 4.847 0 - 2.394	5 4 3 2 1	Highly Vulnerable Vulnerable moderately Vulnerable Less Vulnerable Non Vulnerable
Flow Direction	15	1 – 2m 2– 8m 8 – 32m 32 –6 4m 64 –128m	5 4 3 2 1	Highly Vulnerable Vulnerable moderately Vulnerable Less Vulnerable Non Vulnerable
Land Use/Land Cover	25	Built-up/ Bare-land Water-body Farmland Shrub Forest	5 4 3 2 1	Highly Vulnerable Vulnerable moderately Vulnerable Less Vulnerable Non Vulnerable
Soil Erodibility	20	0.06591 - 0.06698 0.06698 - 0.06782 0.06782 - 0.06866 0.06866 - 0.06956 0.06956 - 0.07199	5 4 3 2 1	Highly Vulnerable Vulnerable moderately Vulnerable Less Vulnerable Non Vulnerable

The weight value provided was adopted from Njoku *et al* (2018) the prioritize factor expressed as a percentage value between 0 and 100%. Using a linear weighted combination, the sum of weight was expressed as 100%. The information in Table 5.2 was applied to generate the distribution of areas vulnerable to flooding. The range of ranking was 1 to 5; the highest influence factor was rank 5 and the lowest influence factor was 1.

For this study, reconnaissance survey showed that inundation mostly occurs during the rainy season in low lying areas. Thus 5 factors are most pertinent- Soil, Land use/Land cover, Flow Direction, (elevation and slope) and rainfall. Going by this, with inclination to the choices of previous authors, Land use/Landcover as assigned the highest weight (25%), the order of normalized weight was Rainfall

(20%), Slope (20%), Soil (20%), Flow Direction (15%), and looking at the weight of each factor, one can see that rainfall, slope and land use/landcover has the highest weight. It implies that rainfall, slope and the land use/landcover of the study area has contributed immensely to flooding than other factors. Rainfall and Slope influence the direction of the runoff or sub-surface drainage. Furthermore, the slope has dominant control of the rainfall of stream flow, duration of flow and duration of infiltration process. As depicted in Table 4.1, the total weight (W) sums up to 100 to enable execution of the weighted overlay analysis. The weighted overlay unions several raster layers using a common measurement scale and weighs each raster according to its assigned importance. Once the weight in each factor was determined, the multi-criteria analysis was performed to produce a flood vulnerable area by using the GIS approach.

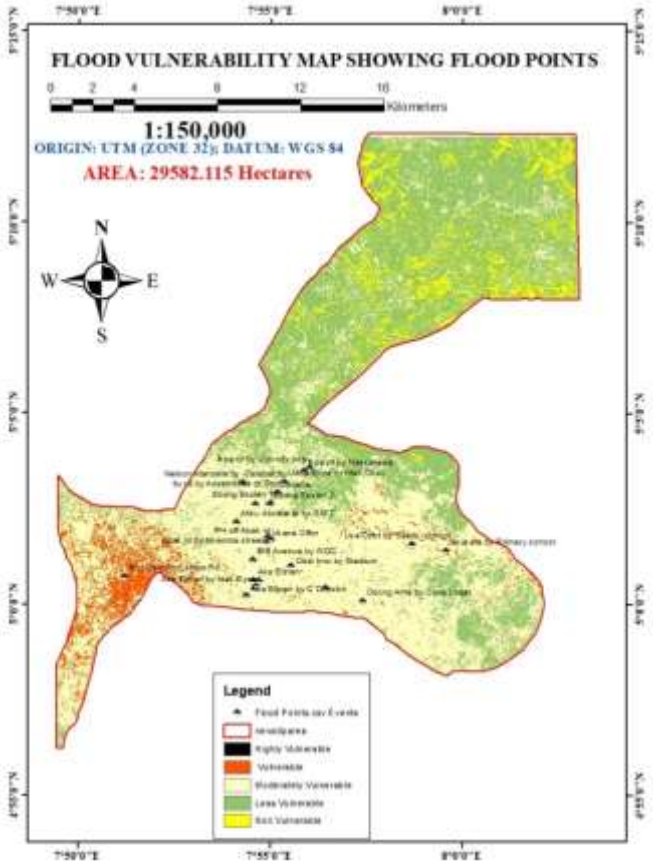


Fig. 8 **Flood Vulnerability Map Showing flood points**

Table 4 Percentage of Flood Vulnerable Zones

Zone	Area covered (Km^2)	Percentage (%)
Non-Vulnerable	19.9413	7
Less Vulnerable	124.767	43
Moderately Vulnerable	133.4502	4
Vulnerable	14.5755	5
Highly Vulnerable	0.027	0
Total	292.761	100

Due to the nature of land use/landcover along this area, heavy rainfall, soil type and topography of the area, the area is most liable to flooding during rainy seasons. As indicated also with the flood vulnerability map, regions around North West of Itu LGA are the areas non floodable due to its high elevation, good natural drainage and soil type while areas within Uyo urban are floodable due to heavy amount of built-up along this area, heavy rainfall, soil and topography of the area. Flood inundation

caused not only economic loss but also caused various diseases such as waterborne disease, vector-borne disease, etc.

From the ground truthing exercise and analysis of the result, it was observed that built up occupied the highest proportion. This implies that there is a heavy presence of human activities in the area. Some of these activities include blockage of drainage routes by refuse, indiscriminate construction and siting of buildings and increase in impervious surface by Asphalt which limit water penetration into the ground. This contributes to excess runoff and subsequent flooding in the study area. Itu LGA is sited near a coastal region and the study area has a low-lying topography. Coastal regions are known for heavy rainfall. Heavy rainfall over a low-lying topography with poor or locked drainage tends to accelerate events of flood menace in the area.

CONCLUSION

Flooding is undoubtedly one of the major global environmental challenges today which have displaced many homes, leading to loss of lives and properties and creating hardship for families and communities in areas where they occur. In Uyo, Itu, and environs, cases of flooding are becoming alarming. Understanding the situation and evaluating the environmental parameters that contribute to this menace will help in designing flood disaster maps which could serve in early warning. From this research, Remote Sensing and GIS have proven to be effective technologies in understanding and assessing events of flooding and other ecological parameters. The flood risk-vulnerability map showed spatial differences in the risk levels within the area. The map provides a tool for instigating effective implementation of mitigation/disaster reduction measures that would decrease the vulnerability and risk faced by the people in Uyo and Itu LGA, especially residents living in the high and vulnerable flood risk zones. The aim of this study which was to assess flood vulnerability erosion from field acquired data and Global satellite datasets of LANDSAT OLI and NASADEM has been achieved. It is believed that the result of this research will serve as a reliable and ready information source for a sustainable flood mitigation measure.

REFERENCES

Adeoye, N. O., Ayanlade, A. and Babatimehin O. (2009). ― Climate Change and Menace of Floods in Nigerian Cities: Socio-Economic Implications, Advances in Natural and Applied Sciences, *3 (3), pp 369 -377*.

African Research Bulletin (2010). Policy and Practice, Economic Trends Benin, Counting the Cost of Floods. Africa Research Bulletin: Economic, Financial and Technical Series, 47 (11), Pages18902–18903, Blackwell Publishing Ltd, Available at http://onlinelibrary.wiley.com/doi/10.1111/j.14/pdf last Assessed March 20, 2015.

BBC News (2017). Nigeria: Flooding don affect 25,000 people for Cross River. Retrieved February2018.Available:https://www.google.com.ng/amp/s/www.bbc.com/pidgin/amp/tori-41393720

Blistanova M, Zelenakova M, Blistan P, Ferencz V. Assessment of Flood Vulnerability in Bodva River Basin, Slovakia. Acta Montanistica Slovaca. 2016; 21(1):1928.

Coburn - Vulnerability and Risk Assessment, Disaster Management Training Programme Module. *United Nations Development Programme*, Cambridge, United Kingdom. 1994; 67-68.

Ekpoh I. J., (2015). Climate Change and Recent Severe flooding in Uyo, Akwa Ibom state, Nigeria. *Global Journal of Sciences*. Vol. 14

Essien E. E., Unigwe-Idoko, Ozioma C., and Nwabueze I. O. (2018). Flood Risk Assessment in Uyo Urban, Nigeria Using Geospatial Tools. International Research Journal of Engineering and Technology (IRJET) Volume: 05 Issue: 06

European Commission (EC) (2007),- Directive 2007/60/EC of the European Parliament and of the Council of 23 October, 2007 on the Assessment and Management of Flood Risks, *Official Journal of the European Union*, L288/27-34.

Jeb, D. N., and Aggarwal, S. P., (2008). Flood Inundation Hazard Modeling of the River Kaduna using Remote Sensing and Geographic Information Systems. *Journal of Applied Sciences Research, 4 (12), pp 1822 -1833*.

News Agency of Nigeria; NAN, (2020). https://www.google.com/amp/s/flood-in-akwa-ibom-state

Orok H. I. A (2011) GIS-Based Flood Risk Mapping of Kano City, Nigeria. *Thesis presented in part-fulfilment of the degree of Master of Science in accordance with the regulations of the University of East Anglia. School of Environmental Sciences, University of East Anglia, University Plain, Norwich*

Samanta S., Koloa C., Pal D. K., Palsamanta B. (2016). Flood Risk Analysis in Lower Part of Markham River Based on Multi-Criteria Decision Approach (MCDA). *Hydrology*. 3(29):1-13.

EFFECT OF TRADE OPENNESS ON REAL ESTATE GROWTH IN NIGERIA

Benjamin Gbolahan Ekemode
Department of Estate Management,
Obafemi Awolowo University, Ile-Ife, Osun-State, Nigeria
E-Mail: ekemodeb@oauife.edu.ng

Abstract
This study examined the effects of trade openness on the growth of the real estate sub-sector of the Nigerian economy with a view to ascertaining the attractiveness of the real estate market in the country. Secondary data were utilized for the study. Quarterly data on the real estate contribution to GDP, trade openness variables such as economic outlook, business confidence and the business constraints affecting the confidence level of investors such as inflation rate, interest rate and exchange rate were obtained from the databases of the National Bureau of Statistics and the Central Bank of Nigeria from 2008 to 2022. The data were analysed using econometric tools such as unit root test and dynamic ordinary least square (DOLS) which is a co-integrating model. The results of the analysis showed that economic outlook and business confidence have negative influence on real estate contribution to GDP. Also, interest rate and inflation rate as business constraints exhibited negative effects on the real estate sub-sector of the GDP. On the strength of these, the study concluded that economic trade indicators negatively influence the contribution of the Nigerian real estate sector to the national economy implying that the market is not appealing and open for international investment.
Keywords*: Real estate, attractiveness, GDP, trade openness, cointegration, Nigeria*

Introduction

Globally, real estate investments have emerged as an alternative asset class in addition to stocks, bonds and infrastructure into which institutional investment capital could be committed (Sirmans & Worzala, 2003). Hence, this emergence has prompted sustained investors participation in the global real estate market (Wong, Higgins, & Wakefield, 2017). Since the turn of the millennium, the advent of globalization fueled by the potential diversification benefits inherent in international real estate investments have prompted institutional investors to focus on cross-border real estate investment most especially into emerging economies where huge but untapped potential for development and investment abounds (Fiorilla, Kapas & Liang, 2012). Apart from this, the role of real estate in contributing to the sustainable development of countries has also been documented a motivating factor for investment decisions (see Mouzughi, Bryde & Al-Shaer, 2014). Thus, real estate assets are precursor of national economic growth and development and such growth could be amplified by foreign direct investment.

Cross-border real estate investments could be regarded as an act of venturing into the unknown where the realization of investment motives are often confronted with uncertain economic climate, unstable political environment as well as steep currency fluctuations (Lieser & Groh, 2010; Farzanegan & Fereidouni, 2014). Therefore, in contemplating cross-border investment decisions, institutional investors are often confronted and limited by the uncertainties in the economic climate as well as the unstable and largely unpredictable institutional characteristics of the desired markets (Poon, 2017). Thus, an understanding of the local market trading conditions vis-à-vis their openness and attractiveness is paramount to investors in making rational investment decisions that would ensure the realization of their investment motives and objectives (Cheung & Ljungqvist, 2021).

Prior researches such as Lee, 2005; Falkenbach, 2009; Lieser and Groh, 2010; Asada, 2022 among others identified three pathways to resolving the challenge associated with attracting foreign real estate investment into any country. The first involves the assessment of the attractiveness of the country's real estate market in general while the second entails the evaluation of the individual market sectors within the country. The third involves the assessment of the real estate investment process itself including the institutional and legal frameworks. While these pathways have been largely investigated and documented in developed real estate markets of UK, United States, Europe and Australia (see Keogh

& D'Archy, 1994; McGreal, Parsa & Kievani, 2002; Lim, McGreal & Webb, 2006), little is known about emerging markets most especially in sub-Saharan Africa despite the presence of huge potential for international trade and investment.

For example, the pioneering study of Keogh and D'Archy (1994) identified property market maturity as an important attribute in cross-border real estate investment. The study documented the essential requirements considered by international institutional real estate investors in understating the market structures of various target European property markets arising from the globalization of the real estate investments. Other studies such as Lee (2005), Lieser and Groh (2010) and Wong *et al*., (2017) documented the international real estate allocation process by evaluating the attractiveness of the individual market sectors and the institutional characteristics conditioning the real estate investment process in developed property markets.

As noted by Jones Lang Lassalle (2014), most property markets in sub-Saharan Africa are perceived as opaque with asymmetric transaction information, thereby making them unattractive for foreign investment inflow. This perception suggests these countries are not captured in the asset allocation strategy of most global investors, financiers and developers. In Nigeria, while international investors have been interested in exploring the investment potential of the real estate market, the lack of information on the openness of the real estate market hampers its visibility and reduces the prospect for foreign investors' participation (Evans, 2013). While some studies (such as Olaleye & Adebara, 2019; Clement, Ogunba & Dugeri, 2018; Dugeri, Omirin & Ogunba, 2014, Thontehh, 2013, Akinbogun, 2012) have investigated the maturity of the Nigerian real estate market, these studies have largely been descriptive, and have not quantitatively evaluated the level of attractiveness of the market for foreign direct investment. None of these studies has statistically evaluated the effect of economic trade indicators such as general economic outlook, business confidence and business constraints on the growth of the Nigerian real estate sector. Thus, the attractiveness of the Nigerian real estate market has not received adequate attention, despite the potential for cross-border investment. This study, therefore, seeks to fill this gap by examining the attractiveness of the Nigerian real estate market through the analysis of the influence of economic trade indicators such as general economic outlook, business confidence, and business constraints on the real estate sub-sector of the Nigerian economy.

Literature Review

The need to understand the level of attractiveness of real estate markets for global investment flow has been a concern of institutional investors, investment analysts, fund managers as well as academics and researchers throughout the world. Thus, several studies have examined the influence of economic openness on real estate investment in several countries. One of the earliest researches is Baum and Schofield (1981). The study investigated the attractiveness of property as a global asset class. It identified the potential of real estate investment as a portfolio diversifier that could provide diversification and risk reduction benefits to institutional investment portfolios when invested in countries other than country of origin. The study advocated increased foreign real estate investment by institutional investors. Worzala (1994) investigated the perceptions of institutional investors in the United Kingdom, Netherlands and Germany towards overseas real estate investment. The motivating factors for making foreign property investments were also examined. The result revealed that majority of the investors perceived the realization of diversification and risk reduction benefits inherent in overseas investments while currency fluctuations and unpredictable transaction costs in the target market could inhibit their investment potential. The study only surveyed the perceptions of investors. It did not empirically analyse the effect of the trade indicators on the attractiveness of the real estate market.

Lee (1999) investigated the attractiveness of real estate markets in Europe and its level of openness to cross-border real estate investment. The real estate investment characteristics of 13 European countries were examined using seven indicators, while the countries were classified into three groups, in order to simplify the allocation choice faced by investors. The investment performance of the three groups was then analysed over the period 1985 to 1997 to see if there are variations in the performance of the differing groups of countries. The study found substantial differences in the performance of the different

countries which was ascribed to the different market structure and the varying institutional mechanisms for real estate investment in these countries. Apart from being conducted in developed markets, this study also suffers from the inability to statistically analyse the influence of trade indicators on real estate market performance. Similarly, McGreal *et al*., (2002) investigated the level of openness of real estate markets by examining the extent to which capital cities in central Europe have adapted to global forces in the development of commercial property markets. Employing a qualitative research methodology, data were obtained from expert opinion based on focus groups interviews conducted on property practitioners in Budapest, Prague and Warsaw supported by evidence from the analysis of market reports. Findings showed that institutional barriers and risk factors such as unavailability of market transaction information, absence of reliable statistical data in predicting demographic trends impose constraints on the attractiveness of the property market for international investment. Apart from being limited to market maturity, one major limitation of this study is its inability to quantitatively analyse the influence of trade indicators on the investment potential of the real estate market. The study was largely limited to the opinion of market participants on its potential for cross-border investment, while trade indicators were not statistically investigated.

The study of Bardhan, Edelstein and Leung (2004) analysed the impact of international economic openness upon residential real estate investments. The study used data on 46 cities in 46 countries across the world obtained from the price and earning across the globe 2000 survey prepared by the United Bank of Switzerland to assess the mechanism from economic openness and trading activity to the real estate sector. Findings established a statistically significant relationship between residential real estate returns and international economic openness indicating that openness is a key determinant of urban residential prices around the world. The study concentrated largely on cities in developed economies, while emerging markets, most especially in Sub-Saharan Africa with huge potential for real estate investment were not considered. Lee (2004) examined the relationship between local market risk and real estate investment potential in the United Kingdom. Analysing macro-economic and property market data extracted from the Global Real Estate Transparency (GRET) Index produced by Jones Lang LaSalle (JLL) in 2004, the study found that the level of corruption in a country and the state of her real estate market maturity is significantly correlated. This suggests that corruption drives the absence of market transparency, implying that containing the menace of corruption is very essential in the execution of international asset allocation strategy into developed and developing economies.

In a global study on 51 countries across developing and emerging economies, Lee (2005) investigated the investment potential and the capacity of real estate markets in these countries to attract global real estate investment inflows. The study employed data obtained from a REP index constructed from the synthesis of variables in individual countries based on the approach specified in the literature to analyse the potential of real estate markets to attract institutional international investments. The study identified the level of expected return, macro-economic indicators or country-specific developments, institutional and political factors as the variables that could determine the attractiveness of a market for global participation. It was, however, limited to the utilization of variables to develop a real estate investment potential index. The actual state of the market and its capacity to attract international investors was not empirically investigated. Lim *et al*., (2006) examined institutional real estate investors' attitudes and perception towards real estate investment opportunities in emerging real estate markets of Central/South America and Africa including Nigeria. Employing data obtained from the cross sectional survey of institutional investors comprising investment managers, pension funds and REITs, the study found that institutional investors are primarily concerned with returns on investment in a secured investment climate. Furthermore, the study attributed the low level of cross-border investments into the property markets of the surveyed countries to the opaque nature of the markets arising from the lack of institutional and economic regulatory frameworks to ensure secured and profitable property investments. While fulfilling its purpose, this study, however, suffers from the limitation of not statistically analyzing the attractiveness of the real estate markets in these countries.

In a study on the openness and competitiveness of real estate markets in 54 countries across Europe, Asia, America and Australia for cross-border real estate investments, Newell (2008) found that the attractiveness and competitiveness of real estate markets for international investment inflow is

determined by economic and trade indicators such as corruption perception index, business sophistication, global competitiveness and their inter-relationship with the operations of the real estate markets. Similarly, Aizenman and Jinjarak (2009) investigated the competitiveness of real estate markets for international capital by analyzing the linkages between capital inflows and real estate markets. Utilizing cointegration models to analyse data obtained from 43 countries comprising 25 OECD countries, the results showed there is increased participation in the real estate markets which is attributable to the significant relationship between the real estate market and national economic indicators. Falkenbach (2009)'s study examined the attractiveness of real estate market for cross-border investment by investigating the market selection criteria of globally investing institutional property investors in Europe for investment international real estate. Employing data primarily obtained from 21 institutional property investors across four European countries through the use of questionnaire, the study established that security of title and property rights, expected rate of return as well as the expected economic growth of the area are the most important market selection criteria for foreign property investment. Apart from being conducted in developed countries of Europe, the study was limited to the analysis of the drivers of market selection from the perspective of investment and asset managers. The study did not statistically analyse the trade indicators that influence the attractiveness or otherwise of real estate markets for investment and allocation decisions.

Salem *et al*. (2009) investigated the attractiveness of Gulf Cooperation Council (GCC) real estate markets to global real estate investors' participation by examining the barriers to cross-border capital inflow into these markets. Employing data through the survey of industry practitioners and Property Funds Research (PFR) Funds database, the findings showed a limited availability of reliable property market information in the GCC markets except Saudi Arabia, making the GCC markets unattractive to global real estate investors. However, this study did not statistically analyse the effect of economic trade indicators on the growth of the real estate market. Lieser and Groh (2010) examined the attractiveness of the real estate markets in 66 countries across the continents of Europe, Latin America, Asia and Australia. It also constructed a composite ranking of countries through the creation of an index. Employing data obtained from the weighing of six identified factors perceived to be influencing cross-border real estate investment into the surveyed countries, the study found the existence of substantial variations in the investment climate of these countries for global real estate investments. It was also noted that institutional real estate investors' market perception and cross-border investment decision making are often influenced by economic, legal, political and institutional strengths and stability. This study is limited by its inability to quantitatively examine the influence of trade indicators on the openness of the assessed real estate markets. It also ignored emerging real estate markets in Sub-Sahara Africa where huge potentials for investment abound.

Jinjarak and Sheffrin (2011) examined the causal relationship between real estate prices and trade indicators such as GDP, interest rates, output growth and equity prices in the developed real estate markets of England, Ireland, Spain and the United States of America. Employing quarterly data, vector auto regression (VAR) was used to analyse the linkage between real estate prices and the economic indicators. The study found strong relationship between interest rates and real estate prices across the four countries. It was also found that trade indicators exhibited significant effects on mortgage markets in the United States indicating the attractiveness of the market for capital inflow. Wang, Yang and Liu (2011) examined the attractiveness of the Chinese real estate market by analyzing the relationship between economic openness and real estate returns in urban areas. Employing data comprising macro-economic indicators as well as real estate market variables across 35 major cities in China from 1998 to 2006, the level of cointegrating relationship between the variables were assessed using logarithmic panel data model and Granger causality. The study found a statistically significant positive relationship between economic openness and real estate asset returns in Chinese urban areas. The findings suggested that economically more 'open' cities have shorter economic distance to the international market with high level of real estate investment activities. Kim, Lin and Suen (2012) investigated the interactions among economic growth, financial and trade openness across 66 countries using econometric modelling. Findings from the study established significant interactions among the three variables. Financial development was found to exert a strong positive effect on trade openness while trade openness exhibited a significant positive relationship with economic growth. This study was a general

investigation of the openness of the overall national economy in the sampled countries, the effect of these trade indicators on the real estate sector was not analysed.

Fereidouni and Masron (2013) investigated the effects of real estate market factors on foreign direct real estate investment. Employing panel data technique to analyse data obtained from 31 countries over the years 2000-2008, the study found that transparency in the real estate market, lower financing costs and higher property prices have significant effects on the level of cross -border investment inflow into the real estate markets. However, the study was only limited to real estate factors, the effect of economic trade indicators on international real estate investment were not analysed. Similarly, Wolski and Zaleczna (2013) examined the potential and attractiveness of the real estate market in Poland for institutional investments. The study found that the polish real estate market is immature thereby limiting investment opportunities in the real estate market. The study only reviewed the Polish position on the global real estate market maturity index in the literature, as well as the diversification potential of real estate assets in mixed asset portfolio. The linkage between the real estate assets and trade indicators was not statistically analysed.

The research of Sa, Towbin and Wieladek (2014) examined the effect of capital inflows and financial structure on the operations of the residential housing sector in 18 OECD countries. The extent of capital inflow shocks were employed to determine the investment attractiveness of the housing sector. Employing an open-economy vector auto regressive model to analyse data comprising 12 economic indicators and residential housing prices, the findings revealed that capital-inflow shocks have a significant and positive effect on house prices, the amount of finance available to the private sector and residential property investment. This finding established the link between investment friendly economic climate and housing development. Similarly, Farzanegan and Fereidouni (2014) investigated the relationship between real estate market transparency and foreign real estate investments for 32 countries covering 2004, 2006, 2008 and 2010 time periods. Employing fixed effect model and generalized method of moment analysis, the study found that there is no significant relationship between real estate market transparency and foreign real estate investments; as a rise in transparency of real estate markets in the sampled countries do not lead to significant increase in foreign real estate investments. Apart from ignoring emerging markets in sub-Saharan Africa, this study only focused on the effect of market transparency. The relationship between trade indicators and the real estate markets which determines the attractiveness of the market for international capital was not analysed.

In a recent study, Wong *et al*., (2017) investigated the drivers of the attractiveness of foreign direct investment in the Australian residential property market by analyzing the relationship between international investments and residential property market performance in Australia. The study employed quarterly data on housing market prices sourced from the ABS and the Real Estate Institute of Victoria (REIV) database from the year 2002 to 2013 to analyse the relationship between residential property performance and economic indicators for trade competitiveness. Using multiple and stepwise linear regression analysis, the findings showed the existence of positive significant relationship between residential property market and foreign direct real estate investment. This was attributed to the upsurge of population through residential migration and tourism. The study also established a significant negative correlation between house prices and foreign exchange rate suggesting that exchange instability against major currencies could hamper the attractiveness of real estate markets. Apart from being conducted in Australia, a developed economy, with differing level of economic sophistication and development with emerging markets, the study employed linear regression to analyse the relationship between the two assets. The inadequacies of linear regression in effectively modeling the relationship between variables have been documented in the literature.

In another recent study, Poon (2017) examined the attractiveness of the UK real estate market by investigating the key drivers of foreign direct investment into the London real estate markets. The study employed data sets comprising quarterly data on six economic indicators from 1987-2015 to model the potential of the real estate market to attract international funds. Utilising fixed effects panel regression and Pearson correlation to model the relationship between economic indicators and real estate investments, the findings showed that economic indicators have statistically significant relationship

with foreign real estate investment indicating the attractiveness of the London property market for international capital. This study however has some limitations. Apart from being conducted in London, a tier one developed and matured real estate market, the study did not analysed the effect of exchange rate, a key driver of international business on the behaviour of the real estate market.

Employing dynamic panel quantile regression, the work of Zhu, Li and Guo (2018) investigated the impact of income, economic openness and interest rates on housing prices in China. The study found that both and income and economic openness have positive and significant effects on the pricing of real estate asset in China which is an indication of its potential to stimulate the growth of the Chinese real estate market. In a recent study, Cheung and Ljunggvist (2021) examine the relationship between trade openness and economic growth with a focus on 31 advanced OECD countries between 2000 - 2018 time period. Employing panel data analysis and linear regression model, the outcome established a statistically significant positive relationship between economic growth and trade openness suggesting that trade openness positive influence economic development. More recently, Asada (2022) examined the impact of trade openness and foreign direct investment inflows on the economic growth of Thailand. This study examines the effects of Thailand's outward-oriented. Adopting the autoregressive distributed lag approach to analyse the collected data, the findings reveals a strong positive long run contribution of trade openness GDP growth to Thailand in the long run, with foreign direct investment exhibiting negative contribution.

The corollary of the foregoing review is that various studies have explored the effect of economic trade openness on the attractiveness of real estate markets. However, a greater proportion of these studies, apart from being conducted in developed markets, focused on the assessment of the level of property market transparency and maturity. A sizeable proportion also focused on deconstructing the effect of trade openness on the general economic without isolating the effect of the real estate sector, a key component of the national economy. Similarly, most of these studies only analysed the perception of investors on real estate market attractiveness. They did not statistically analyse the influence of economic openness on real estate investment. Besides, available emerging African real estate markets studies have largely focused on Nigeria and also restricted to property market transparency. For instance, Akinbogun (2012) evaluated the attractiveness of the residential property market in Nigeria by applying property market maturity attributes to the operations of the market. The study found that the residential property market does not conform to the indicators of market maturity upon which it was assessed. Transactional information was found to be largely unavailable suggesting that the market is closed and invisible for international investment, thereby restricting the flow of foreign direct investment. Apart from ignoring other sectors of the real estate market such as commercial and industrial, the study suffers from the limitation of not empirically analyzing the influence of trade indicators on the attractiveness of the Nigerian real estate market.

Similarly, Udobi *et al*., (2016) evaluated the challenges of international real estate investment in emerging economies, with a particular focus on Nigeria. Employing a desktop review of the literature methodology, the study found that there has been increasing participation of international investors in the Nigerian economy since the advent of democratic governance in 1999 which heralded strong growth and investment opportunities for the real estate markets. The paper observed that despite this strong economic growth and potential investment opportunities within the real estate sub-sector, challenges such as political and structural instability, uncertain economic outlook, property market transparency risk and currency fluctuations continue to limit investor's participation. While achieving its motive, this study did not empirically analyse the influence of these trade indicators on the performance of the real estate markets in the country. The research of Ijirshar (2019) analysed the impact of trade openness on economic growth among ECOWAS countries. The study employed secondary data from 1975-2017 and the data were analysed using cointegration enabled Pooled Mean Group and Hausman tests. The findings exhibited long run positive effects of trade openness on economic growth in ECOWAS countries indicating the trade competitiveness and growth potential of these countries. The study however focused on the general economies of these countries and not the real estate market. More so, Olaleye and Adebara (2019) analysed the role of economic variables in re-examining the framework

for measuring the maturity of the Nigerian real estate market. Focusing on the Lagos property market, analysis of data elicited from 181 estate surveying and valuation firms and 87 property development companies revealed that the Lagos property market was emerging and that the inclusion of economic features in the maturity framework reduced the level of market maturity. The study contended that the state of economic openness of a country significantly impact the attractiveness of its property market.

There is limited study that has statistically analysed the economic openness of the Nigerian real estate market for foreign direct investment. The foregoing suggests that there is little empirical evidence on the level of economic openness of emerging sub-Saharan African real estate markets for international investment. This poses severe consequences for real estate investment decision-making, as prospective international investors would lack the required market intelligence to inform their investment decision-making into the continent's real estate markets. This paper fills the gap by examining the openness and attractiveness of the Nigerian real estate market for international investment.

Methodology

The data utilized for this study comprised macro-economic indicators of economic openness. Learning from the works of Bardhan *et al*. (2004), Aizenman and Jinjarak (2009) and Jinjarak and Sheffrin (2011), quarterly data on economic trade indicators such as general economic outlook, business confidence and business constraints which influence the flow of capital into a national economy were extracted from the publications of the Nigerian Statistical Bureau and the Annual Reports of the Central Bank of Nigeria beginning from Q2 2008 to Q4 2022.
Since economic growth is measured by the average annual growth rate of real GDP, the contribution of the real estate sector to the overall GDP was used as a proxy for the national real estate market (Wang *et al*., 2011). Three components of business constraints namely interest rates, exchange rate and inflation rate were analysed. This is sequel to their identification as the most important variables inhibiting economic growth and trade openness in developing countries (Kim *et al*., 2012). Thus, quarterly data on the real estate sector's contribution to GDP as well as business constraints indicators were also obtained from Q2 2008 to Q4 2022. This gives a total of 39 observations for all the variables analysed.

The time period of Q2 2008 to Q4 2022 was necessitated by data limitation. While, data on real GDP in Nigeria is available from 1965, the contribution of real estate sector to the overall GDP was not available until 1981. Besides, data on economic outlook, business confidence and business constraints became available during the second quarter of 2008. The real estate GDP values were logged using natural logarithm to reduce skewness and normalize the data to ensure ease of computation and analysis.

To determine the effects of economic trade indicators on the real estate sector, the data on the variables were analysed using cointegration techniques. This begins with unit root tests. This was done to ascertain the level of stationarity of the time series variables and determine their suitability for cointegration analysis. In order to discover the stationarity state of the variables, the study utilised both Augmented Dickey Fuller (ADF) and Phillip Perron (PP) tests. Both ADF and PP tests can adequately adjust for serial correlation. The ADF unit root test involves estimating the regression equation for each series. The regression equation for the test is given as (See Hoesli & Oikarinen, 2012 for more details):

$$\Delta y_t = \alpha_0 + \alpha_1 y_{t-1} + \sum_{i=1}^{n} \alpha_1 \Delta y_i + e_t$$

The PP unit root test involves estimating a non-augmented version of the regression equation without the lagged difference terms. It uses a nonparametric method to control for serial correlation. It is thus a modification of the ADF test and takes care of the possibility for structural breaks. The regression equation for the test is given as:

$\Delta y_t = \alpha + bY_{t-1} + \varepsilon_t$
A more detailed discussion is provided in Philip and Perron (1988).

After the data series have been analysed for unit root, the interactions between the variables was examined using the dynamic ordinary least square (DOLS) model. The dynamic ordinary least square (DOLS) is a co-integrating model. The model according to Stock and Watson (1993) has the tendency to capture the efficiency of an estimator. The DOLS estimator is an instrumental estimator for variables integrated at order I(1) regressors even if the other variables are integrated and stationary at other orders. Thus, the DOLS is a useful tool in analyzing interactions between variables that are cointegrated with I(1) regressors as well as those stationary at I(0). It is a simple and efficient approach to estimating the coefficients of a cointegrating relationship, and thus is suitable in analyzing the interactions and influence among variables (Camacho-Gutíerrez, 2010).

Results and Discussions
The outcome of the analysis of data conducted for this study is structured into two sections. The first section discusses the descriptive statistics of the variables while the second reports the outcome of the cointegration analysis conducted to determine the effects of the economic trade indicators on the real estate sector of the Nigerian economy. The results are presented in Tables 1-3.

Descriptive Statistics of the Variables
The descriptive statistics of economic indicators and real estate contribution to the GDP is presented in Table 1. The real estate GDP values were logged using natural logarithm to aid easy computation and to ensure that the estimated coefficient of the model do not suffer from the problem of inconsistency and lack of efficiency.

Table 1: Descriptive Statistics of the Variables Q2 2008 to Q4 2017

	Logged Real Estate GDP	Business Outlook (%)	Business Confidence (%)	Business Constraints		
				Interest Rate (%)	Exchange Rate (%)	Inflation Rate (%)
Mean	3.49	36.75	7.29	51.67	16.37	14.94
Median	3.23	46.9	8.4	51	13.5	15.46
Standard Error	0.02	4.92	2.42	0.99	2.56	2.98
Standard Deviation	0.28	30.70	15.13	6.18	9.75	15.75
Variance	0.02	942.68	228.87	38.24	95.03	248.29
Kurtosis	0.10	-0.52	5.01	0.35	-0.86	-0.06
Skewness	0.79	-0.83	1.22	-0.04	0.19	-0.79
Minimum	2.95	-29	-20	34.9	-6.3	8.1
Maximum	3.39	79.5	66.2	64.2	29.2	22.5
Jarque-Bera	1.36	31.08	0.21	1.08	0.74	1.73
Probability	0.50	0.00	0.90	0.58	0.69	0.42

The mean value of real estate GDP at log is 3.49, while the median is 3.23. It shows that the mean of the variable is greater than its median and this implies the existence of positive skewness. The Jarque-Bera statistics of 1.36 with p-value of 0.50 indicates that the variable of real estate GDP is normally distributed at 5% level of significance. For economic trade indicators, business outlook had a mean of 36.75 with median of 46.9. This suggests the existence of negative skewness. The Jarque-Bera statistics

of 31.08 with p-value of 0.00 revealed that the variable is not normally distributed at five percent level of significance. Furthermore, business confidence had mean and median values of 7.29 and 8.4 respectively. With a Jarque-Bera statistics of 0.21 and p-value of 0.90, the variable exhibited a normal distribution at five percent level of significance. Besides, business constraints variables namely interest rate, exchange rate and inflation rate had mean values of 51.67, 8.37 and 9.94 respectively and were all found to exhibit positive skewness. In addition, the variables also reported Jarque-Bera probability values greater than 0.05, indicating the existence of a normal distribution. The results of the standard deviation of the variables indicate that business outlook has the highest volatility of 30.70, while logged real estate GDP has the lowest standard deviation of 0.28. It is apparent from these results that interest rate has the highest mean values. This indicates that the rate of interest on borrowed capital is extremely high in Nigeria implying that investors could be deterred from investing in the real estate market. Being a capital intensive venture with long gestation period, real estate investment requires lower interest rates to attract investors and stimulate economic growth. Besides, the high standard deviation reported for business outlook suggests that the Nigerian business environment is volatile and could pose some risks to investors.

Cointegration Tests

The results of the cointegration tests conducted on the variables to ascertain the influence of open economic indicators on real estate GDP is presented in this sub-section.

Unit Root Tests

Summarized in Table 2 is the outcome of the Augmented Dickey Fuller (ADF) and the Philip-Perron (PP) unit root tests conducted on the variables in order to ascertain the stationarity conditions of the data series.

Table 2: Unit Root Test of the Variables

	ADF Unit Root Test					Philip-Perron Unit Root Test				
Variables	**Level**	**P-value**	**First Difference**	**P-value**	**Rank**	**Level**	**P-value**	**First Difference**	**P-value**	**Rank**
Logged Real Estate GDP	-0.846	0.7888	-1.9073	0.3237	**I(0)**	-0.8819	0.7770	-1.8186	0.3633	**I(0)**
Business Outlook	-4.3049	0.0024	-13.0043	0.0000	**I(1)**	-4.3049	0.0024	-6.2943	0.0000	**I(1)**
Business Confidence	-4.9526	0.0005	-6.5561	0.0000	**I(1)**	-3.1009	0.0412	-1.6348	0.4481	**I(0)**
Interest Rate	-2.2368	0.1989	-20.4616	0.0001	**I(1)**	0.0026	0.9499	-6.7677	0.0000	**I(1)**
Exchange Rate	-3.7253	0.0097	-7.4733	0.0000	**I(1)**	-3.7253	0.0097	-7.3091	0.0000	**I(1)**
Inflation Rate	-2.1862	0.2156	-5.6977	0.0001	**I(1)**	-2.2388	0.1983	-5.5996	0.0001	**I(1)**

Note: All critical values are at 5% level of significance based on MacKinnon's critical values

As presented in Table 2, the results of the ADF test reveals that at level, only three variables namely business outlook, business confidence and exchange rate were stationary while logged real estate GDP, interest rate and inflation rate were non-stationary. However, at first difference, all the variables except logged real estate GDP were stationary at I(1). Similarly, using PP test, only three variables namely business outlook, business confidence and exchange rate were stationary at levels. However, at first difference, four variables namely business outlook, interest rate, exchange rate and inflation rate were stationary and as such integrated at I(1). Meanwhile, business confidence that was stationary at level failed to converge at first difference indicating that it is stationary at I(0). Real estate contribution to GDP failed to converge at levels for both ADF and PP tests but exhibited strong stationarity at first difference based on PP test, indicating that it is stationary at I(1). Overall, these results suggest the all the variables are stationary at order I(1) except business confidence that is stationary at I(0). The

outcome reflects high level of consistency and stationarity in the data series suggesting that the data series are suitable for cointegration analysis.

Dynamic Ordinary Least Square (DOLS) Analysis

Sequel to the finding of differing levels of stationarity order for the variables where the variables were stationary at order I(1) and I(0) respectively, the variables were subjected to dynamic least square (DOLS) analysis. The DOLS technique is more appropriate for this study due to its incorporation of variables with both I(0) and I(1) orders of stationarity. The results of the dynamic least square analysis conducted to analyse the relationship between real estate GDP which is the dependent variable and economic indicators which were the independent variables are summarized in Table 3.

Table 3: DOLS estimation of Relationship between Independent Variables and Real Estate Contribution to GDP

Dependent Variable	Real-estate GDP		
Variable	Coefficient	t-Statistic	Prob.
Business Outlook	-0.005555	-4.242118	0.0240
Business Confidence	0.001203	0.767664	0.4986
Interest Rate	-0.019103	-10.37993	0.0019
Inflation Rate	-0.000587	-0.283421	0.7953
Exchange Rate	0.000633	0.271894	0.8033
C	9.703389	96.11899	0.0000
R-squared	0.995903		
Adjusted R-squared	0.968593		
Mean dependent variable	8.391653		
S.D. dependent variable	0.110849		
Durbin-Watson	1.9163		

The analysis showed a Durbin Watson coefficient of 1.9163. This indicates the likelihood of no serial correlation. The normality test of the model shows that the residual is normally distributed, affirming the reliability of the results. With an adjusted R-Squared of 0.9685, the results showed that the explanatory economic variables explained about 96.85% of the systematic variations in the dependent variable, real estate GDP. Business outlook has negative relationship with contribution of real estate to GDP, with a coefficient of -0.0055 and p-value of 0.024. This result implied that the general economic outlook of the Nigerian real estate market is negative, indicating the non-attractiveness of the market to international investors. Although not statistically significant, business confidence reported positive relationship with real estate contribution to GDP. This shows that the market is becoming more open with potential to attract investors. Business constraints indicators namely interest rate and inflation rate also reported negative relationship with real estate GDP with coefficients of -0.0191 and -0.0005 as well as insignificant p-values respectively. This implies that increase in interest rate hampers the contribution of real estate to GDP. According to Udobi *et al*. (2016), Nigeria is one of the countries with the highest rate of interest on borrowed capital in the world and this could deter investors in participating in the Nigerian economy most especially in the capital intensive real estate sector. Perhaps, the economic recession experienced in the country from the second quarter of 2015 arising from the crash in the global price of crude oil which led to the unprecedented rise in commodity prices and increasing inflation rates coupled with debilitating effects of the novel Covid-19 and the attendant economic lockdown and human restrictions could explain the negative influence of inflation rate on real estate GDP. However, exchange rate exhibited a low positive relationship with real estate GDP. This shows that exchange rate is not a barrier to investment opportunities in the real estate market. This outcome could plausibly be as a result of the consistent devaluation of the Nigerian currency against international trade currencies to reflect its economic strength.

In the light of these findings, it is apparent that the Nigerian real estate market is still an evolving market. Thus, international investors are required to thread with caution when contemplating cross-border investment into the market and this reinforces the findings in previous studies such as Fereidouni and Masron (2013), Sa *et al.* (2014) and Clement *et al.* (2018) that most emerging markets in sub-Saharan Africa are not attractive to foreign investors, despite the huge investment opportunities that abounds.

Conclusion

This study examined the attractiveness and openness of the Nigerian real estate market to foreign direct investment by analyzing the interactions between the real estate sector's contribution to the GDP and economic trade indicators. It utilized dynamic ordinary least square analysis which is a cointegrating model to analyse the influence of economic trade indicators on the behavior of real estate sector of the economy. After logging the real estate data, the study found that business outlook, interest rate and inflation rate exhibited negative relationship with real estate GDP. This outcome indicates that the real estate sector of the Nigerian economy is negatively influenced by poor business outlook, high interest rate and spiraling inflationary rate which ultimately make the business environment and investment climate unfriendly for investors. It thus implied that the real estate market lacks the impetus to attract foreign direct investment inflow. One plausible reason for this outcome could be the absence of institutional mechanisms as well as a mortgage finance system to avail long term finance for real estate investment. However, business confidence and exchange rate reported positive but statistically insignificant relationship with real estate contribution to GDP. This suggests that despite its unattractiveness, there is potential for investment growth and expansion in the Nigerian real estate market. The recent efforts of the government in strengthening institutions and enforcing regulatory frameworks coupled with the stability of the foreign exchange system could account for this outcome.

Emanating from these findings, the study concluded that economic trade indicators negatively influence the contribution of the Nigerian real estate sector to the national economy implying that the market is not appealing and open for international investment. Thus, institutional investors most especially at the global level are advised to exercise caution when exploring the investment potential in the real estate market. The conclusion of this study should be of benefits to prospective foreign investors seeking to explore the potential of the Nigerian real estate market, as it will aid the making of rational real estate investment decisions. Specifically, foreign investors seeking to invest in the Nigerian real estate market are encouraged to evaluate the general economic outlook of the market taking into consideration the business confidence as well as the constraints underlying the real estate sector and adopt appropriate tactics and strategies to mitigate them before making irrevocable decisions. Overall, these findings underscore the need for the Nigerian government to provide an investor friendly economic climate. Particularly, provision should be made for low interest rate through the creation of a mortgage finance system for real estate investment. Similarly, efforts should be made to reduce the volatility and ensure the stability of the exchange rate system.

Although this study has provided insights into the attractiveness of the Nigerian real estate sector, the findings should be taken with caution. The absence of data on economic trade indicators beyond 2008 could have improved the findings of the study. Notwithstanding, the outcome of the study could enhance investors' understanding of the peculiarities of the Nigerian real estate market.

References

Aizenman, J. and Jinjarak, Y. (2009). Current account patterns and national real estate markets, *Journal of Urban Economics*, 66(2), 75-89.

Akinbogun, S. P. (2012). The application of property market maturity framework to a developing country: The case of Nigeria. Proceedings of the 19th Annual Conference of the European Real Estate Society held in Edinburg, Scotland, 13-16 June, 2012.

Asada, H. (2022), Effects of foreign direct investment, trade openness, and human capital development on the economic growth of Thailand, *International Journal of Asian Business and Information Management*, 13(1), 1-14.

Baum, A. and Schofield, R. S. (1981). Property as a global asset, *Working papers in European Property*, Center for European studies, University of Reading, Reading, United Kingdom.

Bardhan, A. D., Edelstein, R. H. and Leung, C. (2004). Note on globalization and urban residential rents, *Journal of Urban Economics*, 56(3), 505-513.

Camacho-Gutíerrez, P. (2010). *Dynamic OLS estimation of the U.S. import demand for Mexican crude oil, MPRA* Working Paper No. 30608, Texas A & M International University, USA, 13 pp. Available at https://mpra.ub.uni-muenchen.de/30608/. Accessed May 26, 2022.

Cheung, J. and Ljunggvist, Z. (2021), The impact of trade openness on economic growth : a panel data analysis across advanced OECD countries, *B.Sc. Dissertation, Institution of Social Sciences*, Sodertorn University, Sweden.

Clement, C. C., Ogunba, O. A. and Dugeri, T. T. (2018). An evaluation of property market maturity property markts in Southwestern Nigeria, Property Management, Available at **https://doi.org/10.1108/PM-04-2017-0022**

Dugeri, T. T., Omirin, M. M. and Ogunba, O. A. (2014). An examination of the extent to which the Nigerian property market exhibits the characteristics of maturity, Proceedings of the 7th International Real Estate Research Symposium, held at the National Institute of Valuation, Putrajaya, Malaysia, April 29-30, 2014.

Evans, P. (2013). Nigeria has real estate potential and challenges, The Wall Street Journal. Available at:https://www.wsj.com/articles/SB10001424127887324251504578579933994141760 Accessed May 24, 2022.

Falkenbach, H. (2009). Market selection for International real estate investments, *International Journal of Strategic Property Management*, 13(2), 299-308.

Farzanegan, M. R. and Fereidouni, H. G. (2014). Does real estate transparency matter for foreign real estate investments?, *International Journal of Strategic property Management*, 18(4), 317-331.

Fereidouni, H. G. & Masron, T. A. (2013). Real estate market factors and foreign direct real estate investment, *Journal of Economic Studies*, 40(4), 448-468.

Fiorilla, P., Kapas, M. and Liang, Y. (2012). An institutional view of global real estate markets, *Journal of Real Estate Portfolio Management*, 18(1), 123-133.

Hoesli, M. and Oikarinen, E. (2012). Are REITs real estate? Evidence from international sector level data, *Swiss Finance Institute Research Paper Series No. 12-15*, 28pp.

Ijirshar, V. U. (2019), Impact of trade openness on economic growth among ECOWAS countries: 1975-2017, *CBN Journal of Applied Statistics*, 10(1), 75-96.

Jinjarak, Y. and Sheffrin, S. M. (2011). Causality, real estate prices, and the current account, *Journal of Macroeconomics*, 33(2), 233-246.

Jones Lang LaSalle (2014). Real estate raises the bar, data disclosure and technology lift transparency levels, Global Real Estate Transparency Index Team, Chicago.

Keogh, G. and D'Archy, E (1994). Market maturity and property market behaviour: An European comparison of mature and emergent markets, *Journal of Property Research*, 11(3), 215-235.

Kim, Lin & Suen (2012). The simultaneous evolution of economic growth, financial development, and trade openness, *Journal of International Trade and Economic Development*, 21(4), 513-537.

Lee, S. L. (1999). The European real estate market, Paper presented at the International real estate society conference held in Kuala Lumpur, Malaysia, 26-30 January, 1999.

Lee, S. L. (2004). Local Market Risk, Proceedings of the Handbook on International Real Estate, Investment Property Forum (IPF), London.

Lee, S. L. (2005). Gauging the investment potential of international real estate markets, Paper presented at the 12th Annual Conference of the European Real Estate Society held in Dublin, Ireland, 15-18 June, 2005.

Lieser, K. and Groh, A. P. (2010). The attractiveness of 66 countries for institutional real estate investments: A composite index approach, *Working Paper Series WP-868*, IESE Business School, University of Navarra, Spain, 59 p.

Lim, L. C., McGreal, S. and Webb, J. R. (1999). Perception of real estate investment opportunities in Central/South America and Africa, Journal *of Real Estate Portfolio Management*, 12(3), 261-276.

McGreal, S., Parsa, A. and Keivani, R. (2002). Evolution of property investment markets in Central Europe: Opportunities and constraints, *Journal of Property Research*, 19(3), 213-230.

Mouzughi, Y., Bryde, D.and Al-Shaer, M. (2014). The role of real estate in sustainable development in developing countries: The case of the Kingdom of Bahrain, *Sustainability*, 6, 1709-1728.

Newell. G. (2008). Assessing the linkages between economic competitiveness and property market transparency, *Pacific Rim Property Research Journal*, 14(3), 322-333.

Olaleye, A. and Adebara, B.O. (2019), Another look at property market maturity framework and its application to Lagos property market, Nigeria, *Journal of Property Investment and Finance*, 37(5), 486-502.

Philips, P. C. B. and Perron, P. (1988). The great crash, oil price shock and unit root hypothesis, *Econometrica*, 57(6), 1361-1401.

Poon, J. (2017). Foreign direct investment in the UK real estate market, *Pacific Rim Property Research Journal*, 23(3), 249-266.

Sa, F. Towbin, P. & Wieladek, T. (2014). Capital inflows, financial structure and housing booms, *Journal of the European Economic Association*, 12(2), 522-546.

Salem, M., Ross, A., Saci, K., Kirkham, R. and Abdulai, R. (2009). Exploring the attractiveness of GCC real estate markets to global real estate investors, Paper presented at the Annual European Real Estate Society Conference held in Stockholm, Sweden, June 24-27, 2009, 11 pp.

Sirmans, C. F. and Worzala, E. (2003). International real estate investment: A review of the literature, *Urban Studies*, 40(5), 1081-1114.

Stock, J. H. and Watson, M. (1993). A simple estimator of cointegrating vectors in higher order integrated systems, Econometrica, 61(4), 783-820.

Thontteh, E. O. (2013). An appraisal of the extent of market maturity in Nigeria property market, *Journal of Economics and Finance*, 1(4), 33-38.

Udobi, A.N., Kalu,I. U. and Elekwachi, C. M. (2016). Challenges of international real estate investment in an emerging economy: The Nigerian Experience, *Civil and Environmental Research*, 8(3), 90-97.

Wang, S.,Yang, Z. & Liu, H. (2011). Impact of urban economic openness on real estate prices: Evidence from thirty-five cities in China, *China Economic Review*, 22(1), 42-54.

Wong, P. Y., Higgins, D. and Wakefield, R. (2017). Foreign real estate investment, residential tourism and the Australian residential property market, *International Journal of Housing Markets and Analysis*, 10(5), 586-606.

Wolski and Zaleczna (2013). The attractiveness of real estate investment in Polish conditions, *Real Estate Management and Valuation*, 21(3), 62-70.

Worzala, E. (1994). Overseas property investments: How are they perceived by the institutional investor?, *Journal of Property Valuation and Investment*, 12(3), 31-47.

Zhu, H., Li, Z. and Guo, P. (2018), The impact of income, economic openness and interest rates on housing prices in China: evidence from dynamic panel quantile regression, Applied *Economics*, 50(38), 4086-4098.

ASSESSMENT OF INDOOR AIR QUALITY (IAQ) IN SELECTED WARDS OF AHMADU BELLO UNIVERSITY TEACHING HOSPITAL, ZARIA

John Ogwu Igbochi, Manzuma Buhari Mohammed and Mbamali Ikemefuna
Department of Building, Faculty of Environmental Design, Ahmadu Bello University, Nigeria.
Correspondence email – bmmanzuma@abu.edu.ng

Abstract
The quality of air humans breathe is essential for their health and it is important to keep it clean at all times as it is the main factor that impacts human general life quality. This study assessed the indoor air quality (IAQ) of selected wards in ABU Teaching Hospital Zaria with a view to identifying challenges and empirical means of improvement. The parameters of the study are the indoor air quality indicators; temperature, relative humidity, carbon mono-oxide, carbon dioxide, TVOCs, formaldehyde and particulate matters. The study involved measurements and use of a well-structured checklist for relevant data collection in six wards of the hospital. An air quality monitor and Carbon Monoxide Meter (AS8700A) were used to measure the concentration levels of the pollutants. Findings showed that particles were the commonest indoor air pollutants. Results revealed some wards had temperatures and particulate matter 2.5 exceeding the benchmarks. The highest mean Temperature (28.97 ^oC), RH (58.37%), CO (7.33ppm), CO_2 (531.67ppm), TVOC (0.38 mg/m^3), HCHO (0.19mg/m^3), PM2.5 (44.33µg/m^3) and PM10 (49.67µg/m^3) were found in Male Medical Wards A and B and Female Medical Wards A and B. Results of the inferential statistics showed significant differences ($p<0.05$) in concentration levels of the pollutants between the wards. Also, significant relationship was seen between the physical environmental parameter and the contaminants concentration level in the selected wards. It is recommended that Hospitals should provide functioning ventilation, and air conditioning systems in their wards and these systems must be maintained based on the specifications of NESREA and NMHRC.
Keywords: *Air quality, environmental parameters, contaminants, indoor, particulate matter.*

1.0 INTRODUCTION

Air is an invisible gas made up of a mixture of mainly nitrogen and oxygen and is one of the fundamental needs of life for humans, other animals and plants. The quality of air humans breathe is essential for their health. It is becoming increasingly important to keep it clean for the future (Quarcoo *et al*., 2012). Environmental air contains an unpredictable combination of toxics, including particulate matter (PM), aggravation gases, and benzene (Lodovici & Bigagli, 2011). Indoor air quality is perhaps the main factor that impact human general life quality. People inhale $10m^3$ of air each day, and they invest 80–95% of their energy inside. Indoor air contamination can bring about medical conditions and surprisingly an increment in human mortality (Cabral, 2010).

The unpredictable hospital environment requires excellent indoor air quality (IAQ) to secure patients and healthcare workers against emergency hospital contaminations and ward related sicknesses such as, migraines, weariness, eye irritation and skin disturbances (Mahmoud & Mohamed, 2014). Studies have shown that exporsure to poor indoor air quality (IAQ) could prompt lung related infections and blood related medical issues among patients and clinic staff (Brauer *et al*., 2012; Zahra, 2015). The results of a study by Schwartz *et al* (2014) also show that the hospital has an influence on patients' recovery or acquiring infections that may complicate their conditions.

Hospitals act as specific indoor environment with highly vulnerable individuals potentially exposed to various air pollutants exacerbating health risks (Chamseddine & El-Fadel, 2015). Hence, all activities within the hospital environment (both indoor and outdoor) should be well controlled to minimize the exposure of patients and staff at the hospital to air pollutants with respect to short-term exposure limit (OSHA, 2011; Ayodele et al., 2016).

Ahmadu Bello University Teaching Hospital as an environment for healing is required to provide the occupants with a friendly environment. The extent to which the environmental friendliness is achieved can only be ascertained or measured by assessing the performance of the environmental variables and how satisfied and comfortable the occupants are within the hospital environment. Available literature in Nigeria such as those of Ayodele *et al*, (2016);Aniebo *et al*, (2016); Ekhaise *et al*, (2010) shows that researchers dwelt mostly on biological contaminants with few studies on the physical and chemical contaminants.

1.2 Hypotheses

The following pairs of hypotheses were used to guide the study:

H_0: There is no significant difference in the concentration level of the environmental variables/pollutants between the wards.

H_0: There is no significant relationship between the physical environmental parameters (Temperature and Relative Humidity) and the contaminants concentration level in the selected wards.

2.0 LITERATURE REVIEW

2.1 The Concept of Indoor Air Quality (IAQ)

The Environmental Protection Agency, EPA, (2016) defined indoor air quality as "the air quality within and around buildings and structures, especially as it relates to the health and comfort of building occupants. American Society of Heating, Refrigerating and Air-Conditioning Engineers, ASHRAE, (2008) defined acceptable Indoor Air Quality (IAQ) as "Air in which there are no known contaminants at harmful concentrations as determined by cognizant authorities and with which a substantial majority (80% or more) of the people exposed do not express dissatisfaction.

IAQ problems arise from interactions between the building materials, activities that occur in the building, climate and the building occupants (Kike-Parsis, 2018). These problems may arise from inadequate temperature, poor ventilation systems, indoor air contaminants, or from insufficient outdoor air intake (EPA, 2016). In general, the types of pollutants that may affect IAQ are biological, chemical, particles and aerosol pollutants. Biological pollutants include bacteria, fungi, pollen, and animal dander. Chemical pollutants include adhesives, cleaners, solvents, combustion by-products and emissions from floor or wall coverings. Particles and aerosols are solids and liquids suspended in air, from dust, construction, smoking, or combustion (EPA, 2016).

2.2 Types of Indoor Air Contaminants in Hospitals

The normal sorts of air toxins found in clinics indoor conditions are carbon monoxide (CO), carbon dioxide (CO2), unstable natural mixtures commonly known as volatile organic compounds (VOCs), formaldehyde (HCHO) and Particulate matter.

Carbon Monoxide is an odourless, tasteless and colourless poisonous gas produced by the incomplete combustion of fuels. CO is an un-reactive gas and readily penetrates from outdoors without undergoing significant depletion by physical and chemical processes other than by dilution through air exchange. Tobacco smoking is an additional source of temporary CO pollution. Exposure to carbon monoxide may cause angina, reduce the moving capability or even cause mortality (WHO, WHO Guidelines for Indoor Air Quality: Selected Pollutants, 2016).

Carbon dioxide (CO_2) is an odourless and colourless gas, which is a major product of human respiration and is utilized as an important indictor to evaluate indoor air quality, as well as the performance of ventilation systems. Emissions of CO_2 by humans constitute a major portion of indoor pollutants of CO_2 (Wanner, 2013). The other source of CO_2 is combustion of fuels such as kerosene, gas and wood or coal. CO_2 is a simple asphyxiant, which may act as a respiratory irritant.

VOCs are mostly found and emitted from building materials, furnishings and clothing, potable water, combustion appliances, paints and associated supplies, consumer and commercial products, carpets, adhesives and many others (BCA, 2010). Exposure to volatile organic compounds may lead to acute and chronic health effects. Individuals with asthma and respiratory complaints are particularly vulnerable to low dose VOC exposures compared to others, such as nocturnal breathlessness. In addition, low dose VOCs can lead to fatigue, headache, drowsiness, and confusion. Table 1 shows the classification of VOCs.

Table 1: Classification of indoor organic compounds by volatility

Description	Abbreviation	Boiling point range (°C)
Very volatile (gaseous) organic compounds	VVOC	0 to 50-100
Volatile organic compounds	VOC	50-100 to 240-260
Semi volatile organic compounds (pesticides, polynuclear aromatic compounds, plasticizers)	SVOC	240-260 to 380-400
Non-volatile organic compounds	NVOC	

Source: WHO, WHO Guidelines for Indoor Air Quality: Selected Pollutants, 2016

Formaldehyde is a colourless gas having a strong odour with flammable character and can react very actively at room temperature. It serves as a preservative in healthcare facilities such as mortuaries and medical laboratories. Glue, permanent press fabrics, paper product coatings, fibre boards, and plywood release formaldehyde (ASHRAE, 2008). Adverse health effects from formaldehyde exposure may occur from inhalation or direct contact. Table 2 shows a collection of acute health impacts associated with different concentrations of formaldehyde.

Table 2: Acute health effects from formaldehyde exposure

Formaldehyde concentration (ppm)	Observed health effects
<0.05	None reported
0.05-1.5	Neurophysiologic effects
0.05-1.0	Odour threshold limit
0.01-2.0	Irritation of eyes
0.10-25	Irritation of upper airway
5-30	Irritation of lower airway and pulmonary effects
56-100	Pulmonary edema, inflammation, pneumonia
>100	Coma, death

Source: Hines, 2015

Particulate matter refers to solid particles or liquid droplets suspended in the air, which is one of the major sources of air pollution. Respirable particles are particulates with an aerodynamic diameter smaller than 10 microns, which are also known as PM10. Some PM are visible while others are not, except under a powerful electron microscope. The most common sizes are PM0.1 (< 0.1 micrometres), PM2.5 (< 2.5 micrometres), and PM10 (< 10 micrometres). Total particulate matter (TPM) is all Respirable particles. Smaller particles have the greatest health concern because they can travel deep in the lungs and cause heart and lung diseases (Oberdorster, 2000). The populations most affected by PM exposure are people with lung disease, children, and older adults (Liu et al., 2008). Common PM includes dust, dirt, soot, or smoke. Indoor PM sources include activities such as cooking, cleaning (sweeping or vacuuming), and burning (candles, smoking, incense) (Nazaroff, 2004).

2.3 **Healthcare Facility Design Guidelines**

There are no specific design guidelines for healthcare facilities in tropical climates such as Nigeria. Therefore, international guidelines and standards are examined to understand the common desirable design parameters. Table 3 shows the design parameters presented by ASHRAE. There are five parameters which need to be considered, namely, air pressure relationship to adjacent area (APRTAA), minimum changes of outdoor air/hour (MCOAH), minimum total air changes/hour (MTACH), relative humidity (RH%), and design temperature (DT **°C**). The ASHRAE Standard 170 recommends 24°C as the threshold limit for indoor air temperature, with a relative humidity of 30-60 % (ASHRAE, 2008).

Table 3: Design parameters from ASHRAE Standard 170-2008

Function of space	APRTAA	MCOAH	MTACH	RH (%)	DT °C
Class B and C Operating room	Positive	4	20	30-60	20-24
Operating/surgical Cystoscopic rooms	Positive	4	20	30-60	20-24
Delivery room	Positive	4	20	30-60	20-24
Sub sterile service area	N/R	2	6	N/R	N/R
Recovery room	N/R	2	6	30-60	21-24
Critical and intensive care	Positive	2	6	30-60	21-24
Wound intensive care	Positive	2	6	30-60	21-24
New-born intensive care	Positive	2	6	30-60	21-24
Treatment room	N/R	2	6	30-60	21-24
Trauma room	Positive	3	15	30-60	21-24
Medical/Anaesthesia gas storage	Negative	N/R	8	N/R	N/R
Laser eye room	Positive	3	15	30-60	21-24
ER waiting room	Negative	2	12	Max. 65	21-24

Source: ASHRAE, 2008

2.4 **Indoor Air Quality Standards and Guidelines**

The Federal Government of Nigeria through NESREA has developed National Environmental Air Quality Control Regulations the purpose of which is to provide for improved control of the nation's air quality to such an extent that would enhance the protection of flora and fauna, human health and other resources affected by air quality deteriorations (NESREA, 2014). The following are the national or mandatory standards and guidelines for Carbon monoxide (CO), Carbon Dioxide (CO2), Total Volatile Organic Compounds (TVOCs), Formaldehyde (HCHO) and Particulate matter (PM):

Carbon monoxide (CO): The recommended exposure for carbon monoxide should not exceed 9 ppm for eight-hour time weighted average airborne concentration.

Carbon Dioxide (CO2): Standards set forth by the NESREA and ASHRAE 62.1 (NESREA, 2014; ASHRAE, 2007) recommend a threshold limit of 1000 ppm for carbon dioxide for an eight-hour time weighted average airborne concentration.

Volatile Organic Compounds (VOCs): According to the NESREA, (2014), the total volatile organic compounds (TVOC) should not be more than 1.0mg/m^3.

Formaldehyde (HCHO): The recommended limit for an 8-hour time–weighted average airborne concentration exposure for formaldehyde is 0.1 ppm (DOSH, 2005; ASHRAE, 2007).

Particulate Matter (PM): According to NESREA, (2014), maximum exposure limit for PM2.5 is 35μg/m^3 and PM10 is 150μg/m^3.

Air Temperature: This should be maintained at a value not higher than 24°C.

Relative Humidity: Human thermal comfort is influenced by humidity as human body uses evaporative cooling to regulate body temperature. Indoor relative humidity is recommended to be between 30 and 65 percent (NESREA, 2014).

3.0 **METHODOLOGY**

3.1 **Research Design**

This research was designed to be a field survey. A structured checklist was prepared to guide the study. The measurements were done by using appropriate scientific equipment. The survey procedure involved selection of samples and seeking permission to carry out task, identifying suitable points of measurements, reading and recording measurements and conducting statistical analysis.

The study was conducted in Ahmadu Bello University Teaching Hospital, Shika which is a suburb of Zaria in Kaduna state. It is located in the Northern part of Nigeria, with a geographical position between East longitudes 7° 34' 00" – 7° 46' 00" and North latitudes 11° 02' 00" – 11° 12' 00", with an altitude of between 500 and 700 meters above sea level. Zaria and its environs are characterized by a tropical climate, a monthly mean temperature ranging from 13.8°C to 36.7°C and an average annual rainfall of 1092.8mm. It is a dual city and centre of activities with an estimated population of 897,453 and growth rate of 3.5% per annum and a density of 1,360.7/ km^2 (Manzuma *et al*, 2018; NPC, 2006).

The population of the study includes wards in Ahmadu Bello University Teaching Hospital Zaria. There are a total number of twenty-three (23) wards and six hundred (600) bed spaces (BS) in the Hospital. The wards constitute the population of the study. Table 4 shows the name of wards in the Hospital.

The criteria for selection of the study samples were accessibility to the wards and also wards where the patients were not only conscious but also not in too much pain. Table 5 shows the six (6) wards that satisfied the requirement. The measurements were based on samples drawn from the selected wards.

Table 4 Name of Wards in Ahmadu Bello University Teaching Hospital Zaria

S/N	Name of Wards	BS
1	Male Medical Ward A	50
2	Male Medical Ward B	50
3	Female Medical Ward A	50
4	Female Medical Ward B	50
5	Maternity Ward	25
6	Gynae Ward	20
7	Emergency Paediatric Unit (E.P.U)	20
8	Paediatric Medical Ward (P.M.W)	20
9	Paediatric Surgical Ward A (P.S.W)	20

10	Paediatric Surgical Ward B (P.S.W)	20
11	Special Care Baby Unit (S.C.B.U)	20
12	Surgical Ward (Male)	20
13	Surgical Ward (Female)	20
14	Orthopaedic Ward (Male)	25
15	Orthopaedic Ward (Female)	25
16	Maxillo Facial Unit (M.F.U) (Male)	20
17	Maxillo Facial Unit (M.F.U) (Female)	20
18	Labour Ward	25
19	Neuro-Surgical Ward	20
20	Accident and Emergency (A&E)	20
21	Cardio Thoracic Ward	20
22	Psychiatric Ward (Male)	20
23	Psychiatric Ward (Female)	20

Table 5: Selected Wards in ABUTH Zaria

S/N	Name of Ward	Notation
1	Male Medical Ward A	A
2	Male Medical Ward B	B
3	Female Medical Ward A	C
4	Female Medical Ward B	D
5	Orthopaedic Ward (Male)	E
6	Orthopaedic Ward (Female)	F

3.2 Data Collection

Instruments for Data Collection

The instruments that were used for the collection of data are a checklist, Air quality monitor (TUYA WIFI) and Carbon Monoxide Meter (AS8700A). The checklist was divided into two sections: A and B. Section A included general and geometric information about the wards. Section B entails the likely sources of pollutants in the ward.

Air quality monitor as shown in Plate I is a portable multifunctional tool ideal for monitoring the air quality in the indoor environment. It detects Temperature, Relative Humidity, Carbon dioxide (CO_2), TVOC, Formaldehyde (HCHO), and Particulate matter <2.5 micro-sized particles (PM2.5, PM10) with clock, recording and WIFI function.

Plate 1: Air quality monitor

Plate 2: Carbon Monoxide Meter

The tool measures temperature in the range -10 - 50°C, RH in the range 20 – 85%, CO_2 in the range 400 – 5,000ppm, TVOC in the range 0.000 – 9.999mg/m^3, HCHO in the range 0.000 – 1.999mg/m^3, and Particulate matter (PM2.5, PM10) in the range 0-999µg/m^3.
The Carbon monoxide meter is a portable handheld device (Plate 2) for detecting carbon monoxide (CO). It can continuously monitor CO in an indoor environment and once the gas concentration reaches the level of the inbuilt alarm system, it sounds, lights and vibrates. It can measure CO in the range 0 – 999ppm. This detector was used to quantify the amount of CO present in the wards studied.

Data Collection Procedure
A walkthrough survey of each ward was performed using a checklist to collect the needed data. Measurement of pollutants' concentrations were done following the procedure outlined below:
Sampling Locations: Each ward was sampled on three separate days for a total of twelve sampling days. There were six cubicles in each of the wards sampled.
Sampling Session: Sampling times were selected in an attempt to collect data during potential high activity and a time of minimal activity. The Sampling was between the hours of 10:00am and 3:00pm. This was because medical personnel conduct ward rounds from 08:00am to 10:00am, while the visitation time is from 03:30pm to 05:00pm. To avoid disruption and interference with data collection as a result of visitors' activities, the data collection was restricted to five hours each day.
Calibration of the Equipment: Each instrument was calibrated according to the manufacturer's instructions before each use.
Positioning of the Equipment: The Air quality monitor and CO Meter were placed according to the manufacturers' instructions i.e., away from all walls, openings, corners and at different sampling points in the various wards.

Handling of the Equipment:
The Air quality monitor was placed at 1 – 1.5m above the floor for 5 minutes average sample and the results were displayed on the screen of the instrument.
CO Meter was held at 1.5m above the ground at the various sampling points of the wards for 2 minutes average sample and was not allowed to be close to the wall, door or any active heating system and placed away from sources of potential contaminants. The results were displayed on the screen.
Documentation of Results: The readings were recorded on a sampling form.
The Precision Requirements: Air quality monitor calibrate in 200 seconds for start-up of the analyser and 60 seconds recalibration for new measurement. CO meter was calibrated before the start of new measurement.

3.3 Data Analysis
Both descriptive and inferential statistics were used to analyse the data. The descriptive statistics (arithmetic mean) was used for interpretation of the data and the data was presented in a more meaningful way.
Inferential statistics was used to test hypothesis about the relationship between pairs of variables and how strongly the variables are related. The Pearson Correlation and One-way ANOVA was used to determine whether there was any linear relationship and differences between the selected pollutants and the sampled wards. The Tukey multiple comparison post hoc test, was performed on significant ANOVA findings to identify significant pairwise differences between wards and their environmental variables/pollutant concentration. A Probability value (p-value) of ($p<0.05$) was used for all the analyses.

4.0 RESULTS
Characteristics of the Wards
The physical features of the wards such as the type of floor finish, material of construction of external doors, availability or otherwise of functional fans, air conditioners and exhaust systems were assessed using the checklist. Table 6 shows the findings.

Table 6: Wards characteristics

Wards	Floor finish	Presence of AC	Presence of Fans	Door Material	Exhaust fans
A	Terrazzo	No	Yes	Wood	No
B	Terrazzo	No	Yes	Wood	No
C	Terrazzo	No	Yes	Wood	No
D	Terrazzo	No	Yes	Wood	No
E	Tiles	No	Yes	Wood	No
F	Tiles	No	Yes	Wood	No

Likely Sources of Indoor air pollutants in the Wards

Data was collected on perception of odours, quality of housekeeping, conditions of floors, doors and windows. Table 7 presents the observations.

Table 7: Indoor Air Quality Parameters in the Selected Wards

Wards	Housekeeping	Perceived odour	Doors	Windows	Floors
A	Poor	Strong	Poor	Poor	Average
B	Poor	Strong	Poor	Poor	Poor
C	Poor	Average	Good	Good	Poor
D	Average	Strong	Good	Good	Average
E	Good	Mild	Average	Average	Good
F	Good	Mild	Average	Average	Good

The house keeping in the male (E) and female (F) orthopaedic wards were rated good followed by Female Medical ward B (D) with an average rating. Male medical wards (A and B) and Female medical ward A (C) were rated Low. This could be due to the high number of patients admitted into these wards as a direct relationship has been observed between the population in the wards and the quality of housekeeping. A similar trend is also established for the perceived odours in the wards. The poor condition of the doors and windows in some of the wards could have also contributed to the problems.

Environmental Variables in the Wards

The readings of the environmental variables were taken from the six wards at three different times and the average determined and used for the analyses.

A. Temperature

Figure 1 shows the mean temperature levels in the wards. The highest mean level of 28.97^{o}C was found in Ward B followed by Ward A (28.33^{o}C), while the lowest was recorded in Ward F (23.80^{o}C). The mean temperature in all the wards with the exception of F is higher than the prescribed value of less than 24^{o}C (ASHRAE, 2007). The only obvious reason that could be attributed to this is the higher population of patients in the other wards since Figure 1 is displaying almost a direct relationship between temperature and population of the wards. The conclusion from this result is that the ventilation provision in the wards except F need to be improved so as to bring down the temperatures.

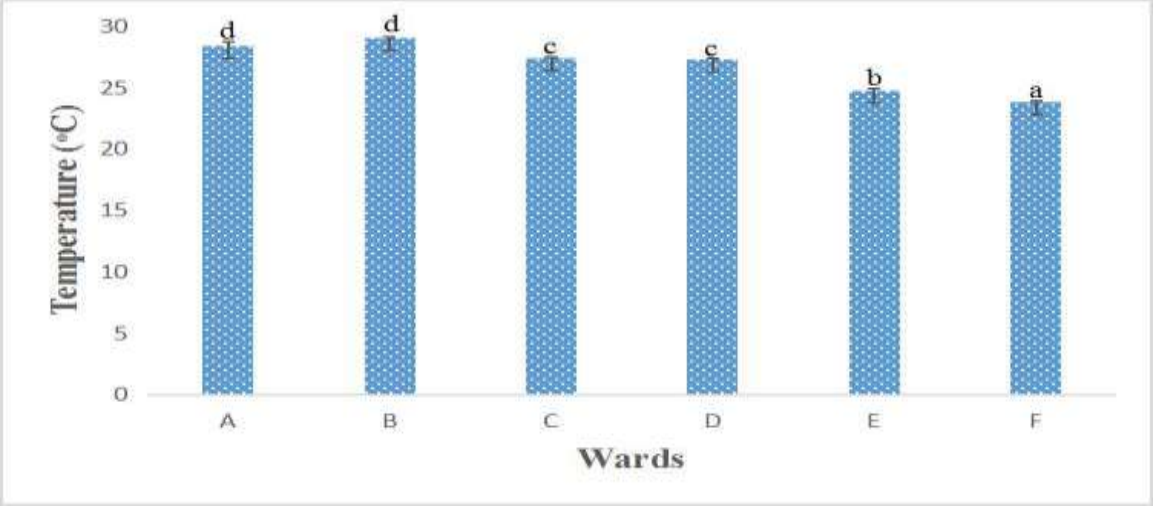


Figure 1: Temperature in the Selected Wards

Relative Humidity

The indoor air quality and thermal comfort also depend greatly on the humidity level, which enhances the microbial growth, increases heat index, and the level of the fine airborne particles. The relative humidity should be set at a higher percentage (40 – 60%) for patient wound recovery in wound intensive care wards (ASHRAE, 2008). Figure 2 shows the RH levels in the selected wards.

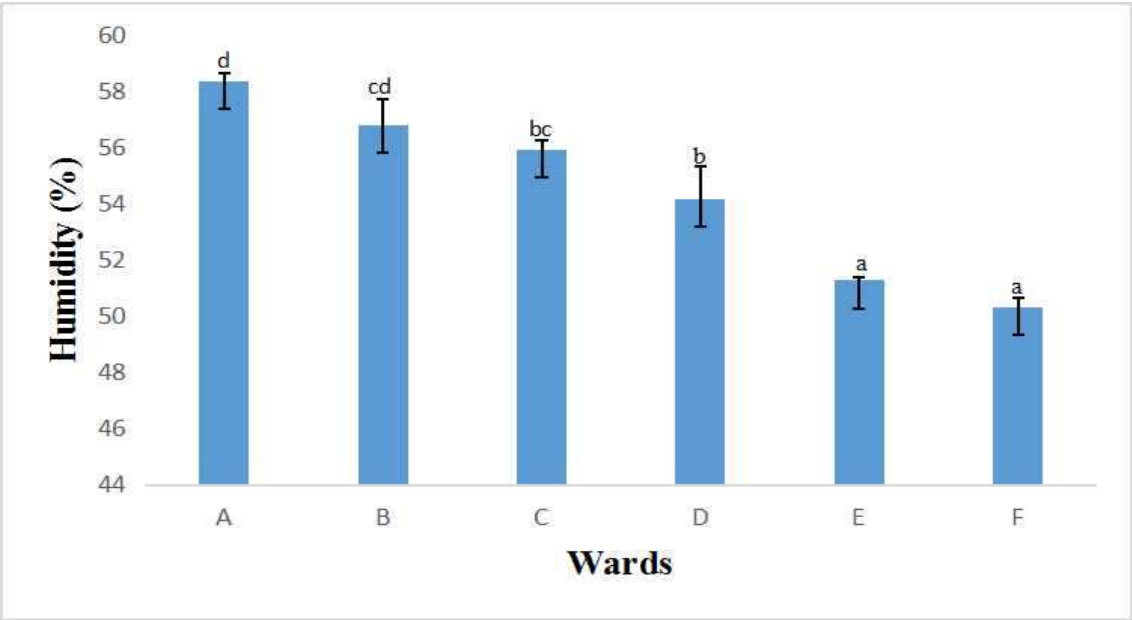


Figure 2: Relative Humidity recorded in the Selected Wards

The RH (58.37%) decreases from the ward with the highest population (A) to the ward with the lowest population, F, (50.33%). All the values are however within the prescribed range.

Mean Concentration Level of indoor air pollutants in the Wards

The Mean concentration levels were measured in the six wards for these pollutants: carbon mono-oxide (CO), carbon dioxide (CO_2), volatile organic compounds (VOCs), formaldehyde (HCHO) and particulate matter (PM2.5 and PM10).

Carbon mono-oxide (CO)

CO is a colourless, odourless and tasteless gas, so it is quite hard to be detected by humans. Figure 3 shows the CO emitted from the studied wards. According to NESREA (2014) and WHO (2016) the concentration levels of CO should not exceed 9ppm.

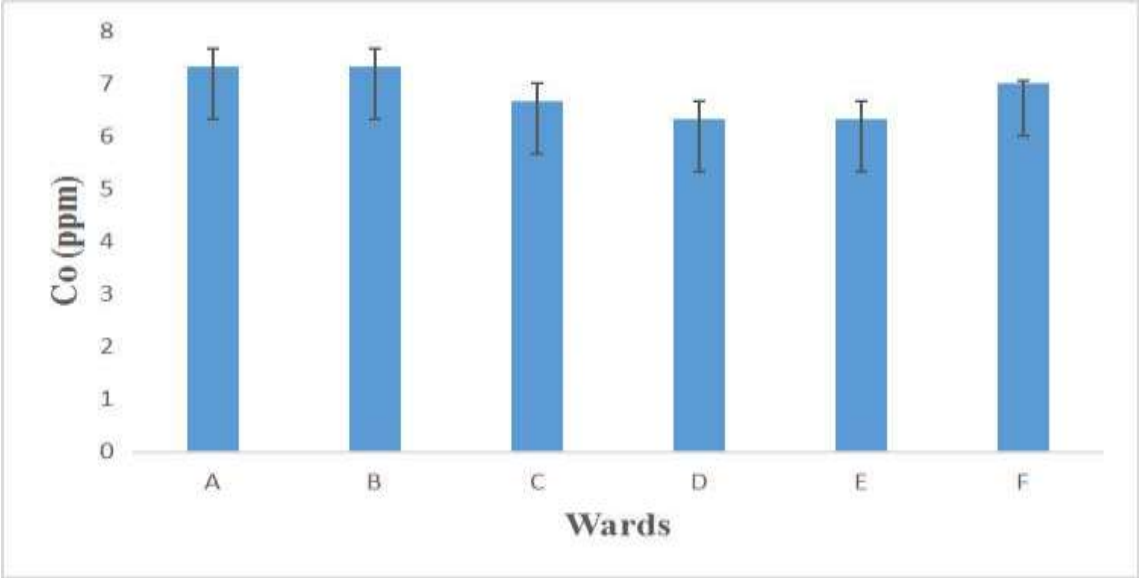


Figure 3: Carbon monoxide emitted from the Selected Wards

The highest mean level of 7.33ppm was found in Wards A and Ward B followed by Ward F (7ppm), while lowest values were recorded in Wards D and E (6.33ppm). The findings of the study showed that all the various sampled wards have CO concentrations that are within the standard values designated by NESREA and WHO. This means that there is no problem in the indoor air quality at the selected wards in terms of CO.

Carbon dioxide (CO_2)

Carbon dioxide (CO_2) is an odourless and colourless gas, which is a major product of human respiration. Exposure to extremely high level will cause some health symptoms such as nausea, dizziness and headaches. The concentrations of CO_2 also affect the perception of motion, by moderating the activity of cells within the visual cortex. ASHRAE standard 62.1 (ASHRAE, 2007) recommend a threshold limit of 1000 ppm for carbon dioxide for an eight-hour time weighted average airborne concentration.

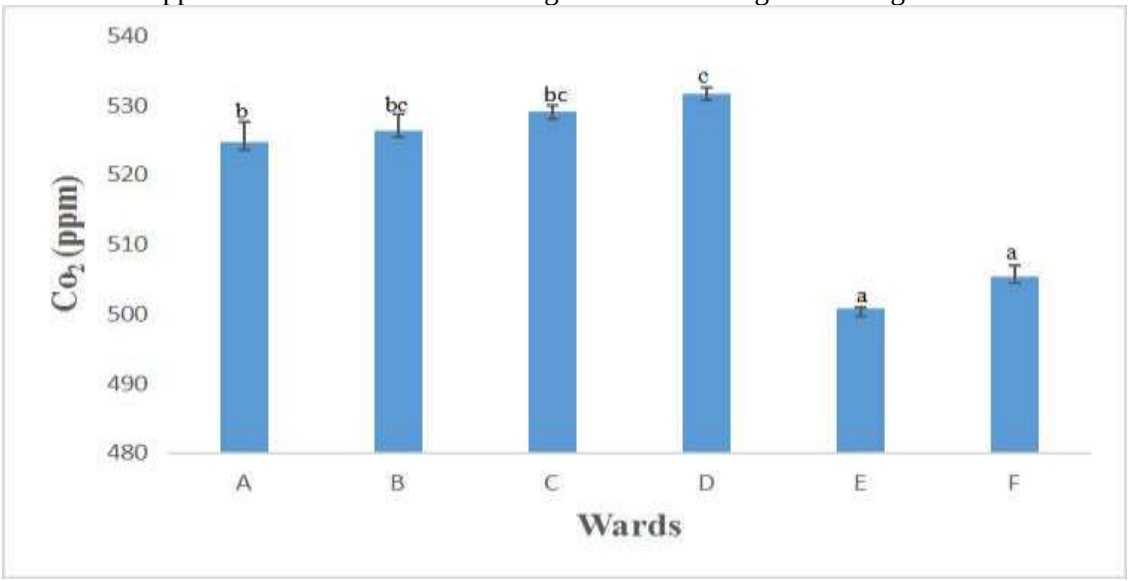


Figure 4: Carbon dioxide emitted from the Selected Wards

From figure 4, the highest mean level of (531.67ppm) was found in ward D followed by ward C (529.00ppm), while lowest was in ward E (500.67ppm). All readings are within the recommended value implying no problem with indoor air quality in the selected wards in terms of CO_2 concentration.

Volatile organic compounds (VOCs) and Formaldehyde (HCHO)

Figure 5 shows the TVOC and HCHO emitted from the selected wards. The highest mean concentration of VOCs (0.38mg/m^3) was in ward C followed by ward F (0.35mg/m^3), B (0.32mg/m^3), A (0.31mg/m^3), E (0.31mg/m^3) while the lowest concentration was recorded in ward D (0.29 mg/m^3). The highest mean concentration of HCHO (0.19mg/m^3) was recorded in ward C followed by A and D (0.17mg/m^3), F (0.16mg/m^3), E (0.15mg/m^3) and B (0.13mg/m^3). All the wards have concentrations of VOCs and HCHO that are within the recommended maximum.

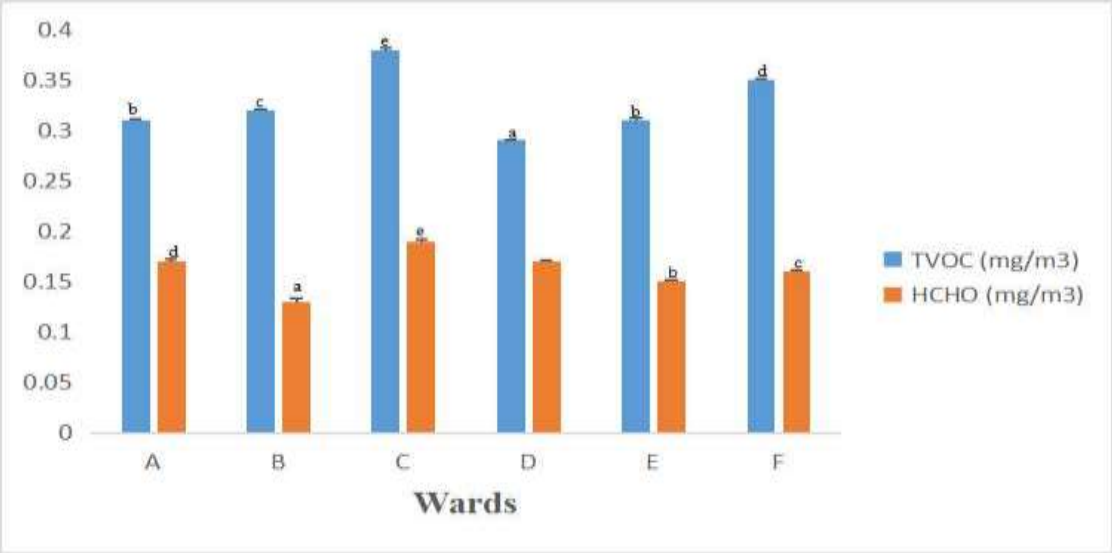


Figure 5: TVOC and HCHO emitted from the Selected Wards

A. Particulate matters (PM2.5 and PM10)

The maximum exposure limit for PM2.5 is 35µg/m^3 and for PM10 it is 150µg/m^3 (EPA, 2016). Figure 6 shows the PM2.5 and PM10 emitted from the selected wards.

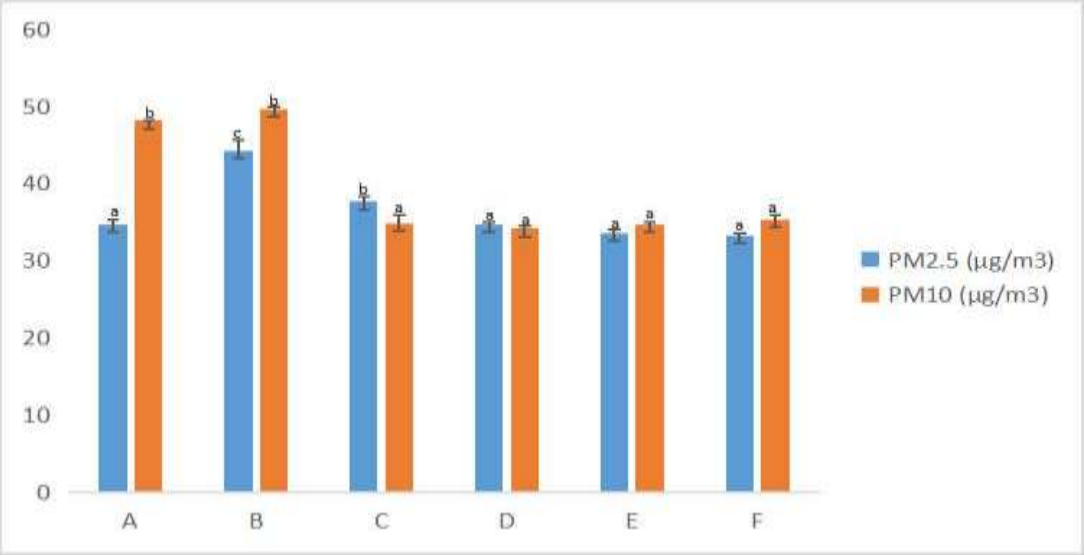


Figure 6: PM2.5 and PM10 emitted from the Selected Wards

The highest mean concentration level of PM2.5 (44.33µg/m^3) and PM10 (49.67µg/m^3) were recorded in Ward B. The second highest concentration of PM2.5 was recorded in ward C (37.67µg/m^3) while the

lowest concentration of 33.33µg/m^3 was registered in ward F. For PM10, ward A closely follow B with a concentration of about 48.20µg/m^3. It can be seen from Figure 6 that the levels of PM2.5 in wards B and C are higher than the recommended maximum while for PM10, the amount in all the wards are below the maximum set limit. It is difficult to attribute these results to any obvious reason because the housekeeping as can be seen in Table 7 is rated poor in wards A, B and C but both the doors and window conditions are poor in wards A and B but good in ward C. The results cannot also be easily associated with materials since the materials for door and floor finish in these three wards are the same. An interaction of a number of factors is a more plausible explanation for these results.

ANOVA of Environmental Variables in the Wards

This test was carried out to check hypothesis (i) which states that there is no significant difference in the values of environmental variables and pollutant concentrations between the wards. Tables 8 and 9 shows the ANOVA of environmental variables and contaminants emitted from the selected wards.

Table 8: ANOVA of Environmental variables and contaminants emitted from the wards.

Wards	Temp **(Mean ± S.E)**	RH **(Mean ± S.E)**	CO **(Mean ± S.E)**	CO_2 **(Mean ± S.E)**
A	28.33 ± 0.44^{d}	58.37 ± 2.7^{d}	7.33 ± 0.33	524.67 ± 2.91^{b}
B	28.97 ± 0.12^{d}	56.80 ± 0.92^{cd}	7.33 ± 0.33	526.33 ± 2.33^{bc}
C	27.40 ± 0.10^{c}	55.93 ± 0.35^{bc}	6.67 ± 0.33	529.00 ± 1.00^{bc}
D	27.27 ± 0.12^{c}	54.17 ± 1.17^{b}	6.33 ± 0.34	531.67 ± 0.88^{c}
E	24.73 ± 0.14^{b}	51.27 ± 0.13^{a}	6.33 ± 0.33	500.67 ± 0.33^{a}
F	23.80 ± 0.10^{a}	50.33 ± 0.33^{a}	7.00 ± 0.00	505.33 ± 1.67^{a}
F	94.747	23.874	2.280	56.068
P-Value	0.000	0.000	0.112	0.000

Data analyzed using One–way ANOVA followed by Tukey multiple comparison post hoc test. Values along the same column with different superscripts [a, b], and [c] are significantly different ($p < 0.05$).

As can be seen in Table 8, the ANOVA statistics indicates no significant difference in temperature between wards A and B but there are significant differences between them and all other wards. Similarly, wards C and D have no significant difference in temperature but are both significantly different from all other wards. Similar explanations can be given for relative humidity and CO_2 but for CO, there is no significant difference in concentration across all the six wards ($p>0.05$).

From Table 9, the ANOVA statistics indicated that the TVOC in all the wards with the exception of A and E are significantly different from each other. HCHO concentrations are also significantly different across the wards except wards A and D. There are no significant differences in the PM2.5 levels in wards A, D, E and F but the levels in wards B and C are significantly different from them and from themselves.

Table 9: ANOVA of contaminants emitted from the selected wards.

Wards	TVOC **(Mean ± S.E)**	HCHO **(Mean ± S.E)**	PM2.5 **(Mean ± S.E)**	PM10 **(Mean ± S.E)**
A	0.31 ± 0.001^{b}	0.17 ± 0.003^{d}	34.67 ± 0.67^{a}	48.20 ± 0.11^{b}
B	0.32 ± 0.001^{c}	0.13 ± 0.003^{a}	44.33 ± 1.33^{c}	49.67 ± 0.26^{b}
C	0.38 ± 0.002^{e}	0.19 ± 0.002^{e}	37.67 ± 0.67^{b}	34.83 ± 1.17^{a}
D	0.29 ± 0.000^{a}	0.17 ± 0.001^{d}	34.67 ± 0.33^{a}	34.16 ± 0.44^{a}
E	0.31 ± 0.000^{b}	0.15 ± 0.002^{b}	33.67 ± 0.33^{a}	34.67 ± 0.33^{a}
F	0.35 ± 0.002^{d}	0.16 ± 0.001^{c}	33.33 ± 0.33^{a}	35.33 ± 0.66^{a}
F	448.770	76.156	34.970	147.791
P-Value	0.000	0.000	0.000	0.000

Data analyzed using One–way ANOVA followed by Tukey multiple comparison post hoc test. Values along the same column with different superscripts [a, b], and [c] are significantly different ($p < 0.05$).

Table 9 shows no significant difference in the levels of PM10 between wards A and B but are both significantly different from all the other wards. Wards C, D, E and F are significantly indifferent from one another. These results have shown that there are significant differences in the values of environmental variables/pollutants concentrations between the wards. Hence the null hypothesis is rejected.

Correlation of Environmental Parameters and The Contaminants Concentration Levels

Inferential statistical analysis was conducted to test the relationships that may exist between the physical environmental parameters (temperature and RH) and the contaminants concentration levels in the selected wards. This statistical test was carried out to check hypothesis (ii) which states that there is no significant relationship between the physical environmental parameters (temperature and RH) and the contaminants concentration levels in the selected wards.

Table 10 is a correlation matrix of the environmental variables and the indoor air contaminants. A positive correlation coefficient means that as the value of one variable increases, the value of the other variable increases or as one decreases the other decreases. A negative correlation coefficient indicates that as one variable increases, the other decreases or as one variable decreases the other increases. A correlation less than 0.2 is described as very weak, 0.2 – 0.399 is weak, 0.4 – 0.599 is moderate, 0.6 – 0.799 is strong while 0.8 and above is described as very strong (Schobar, Boer & Schwarte, 2018**).**

Table 10: Relationship between the environmental parameters and the Air Contaminants

Variables	Temp	RH	CO	CO_2	TVOC	HCHO	PM2.5	PM10
Temp	-							
RH	0.911	-						
CO	0.272	0.408	-					
CO_2	0.848	0.781	0.097	-				
TVOC	-0.106	0.008	0.043	0.063	-			
HCHO	0.079	0.199	-0.239	0.461	0.499	-		
PM2.5	0.661	0.471	0.262	0.447	0.132	-0.364	-	
PM10	0.691	0.699	0.579	0.318	-0.247	-0.442	0.609	-

The correlation matrix in Table 10 shows very strong positive relationships between temperature and RH and temperature and CO_2. This is against the established inverse relationship between temperature and humidity (Brennan, 2018). The implication of this is that there are other factors that influence either the relative humidity or temperature or both of them which this study could not identify. The relationships between temperature and PM2.5, temperature and PM10, RH and CO_2, RH and PM10 and PM2.5 and PM10 are all positive strong relations. As can be seen in Table 10, other relationships exist amongst the variables. Since there are significant relationships between the physical environmental parameters (Temperature and RH) and the contaminants concentration level in the selected wards, the null hypothesis is hereby rejected.

5.0 Conclusion and Recommendations

The major conclusions from the findings of the study are that the temperature and PM2.5 are the most prominent issues causing IAQ problems in the studied wards of Ahmadu Bello University Teaching Hospital Zaria. This is because they exceed the recommended maximum value in some wards. There are significant differences in the concentration levels of the environmental pollutants between the wards and significant relationships also exist between the physical environmental parameters and the contaminants concentrations in the wards.

It is recommended that measures that will lead to quick evacuation of the vitiated air from the wards like improved ventilation systems should be installed. Routine and timely maintenance of facilities

should be upheld. Overcrowding of the wards with patients, their relations and visitors should be avoided by the management of the hospital.

REFERENCES

Aniebo, C., Stanley, H., & Onwukwe, C. (2016). Assessment of the Indoor Air Quality of Majors' Biological Laboratories in Ofrima Complex, University of Port-Harcourt, Nigeria. *J Pet Environ Biotechnol, 7*(4). doi:10.4172/2157-7463.1000285

ASHRAE. (2007). *ANSI/ASHRAE Standard 62.1-2007, Ventilation for Acceptable IAQ.* Atlanta, USA: American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.

ASHRAE. (2007). *Ventilation for Acceptable Indoor Air Quality.* Atlanta: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

ASHRAE. (2008). *ANSI/ASHRAE Standard 170, Ventilation of Health Care Facilities.* Atlanta: American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.

Ayodele, C., Fakinle, B., Jimoda, L., & Sonibare, J. (2016). Investigation on the ambient air quality in a hospital environment. *Environmental Science, 2*, 1-10. doi:10.1080/23311843.2016.1215281

BCA. (2010). *Guidelines for Good Indoor Air Quality in Office Premises*. Retrieved from Building & Construction Authority: www.bca.gov.sg/greenmark/others/NEA_Office_IAQ_Guidelines.pdf.

Brauer, M., Amann, M., Burnett, R., Cohen, A., & Dentener, F. (2012). Exposure assessment for estimation of the global burden of disease attributable to outdoor air pollution. *Environmental Science and Technology, 46*, 652-660.

Brennan, J. (2018): What Happens to Relative Humidity as Air Temperature Rises? Retrieved from https://sciencing.com/relationship-between-moisture-temperature- 4007.html

Cabral, J. (2010). Can we use indoor fungi as bio indicators of indoor air quality? Historical perspectives and open questions. *Science of the total environment*(408), 4285-4295.

Chamseddine, A., & El-Fadel, M. (2015). Exposure to air pollutants in hospitals: indoor–outdoor correlations. *The Built Environment, 2*, 707-716. doi:10.2495/SD150622

Ekhaise, F., Isitor, E., Idehen, O., & Emogbene, O. (2010). Airborne microflora in the atmosphere of an hospital environment of University of Benin Teaching Hospital(UBTH), Benin City, Nigeria. *World Journal of Agricultural Science, 6*, 166-170.

EPA. (2016). *Introduction to Indoor Air Quality*. Retrieved February 2018, from https://www.epa.gov/indoor-air-quality-iaq/introduction-indoor-air-quality

EPA. (2016). *Introduction to Indoor Air Quality.* Retrieved January 10, 2020, from https://www.epa.gov/indoor-air-quality-iaq/introduction-indoor-air-quality

Hines, A. (2015). *Indoor Air - Quality and Control*. Prentice-Hall, Englewood Cliffs, NJ.

Kike-Parsis, A. (2018). *Indoor air quality*. Retrieved from Part 1- What is it.: http://www.medscape.com/viewarticle/494503_4

Liu, L., Box, M., & Kalman, D. (2008). Exposure assessment of particulate matter for susceptible populations in Seattle. *Environmental Health Perspectives, 111*(7), 909.

Lodovici, M., & Bigagli, E. (2011). Oxidative Stress and Air Pollution Exposure. *Journal of Toxicology*, 40-49. Retrieved from http://dx.doi.org/10.1155/2011/487074

Mahmoud, F.-S., & Mohamed, E. (2014). Indoor air quality levels in a University Hospital in the Eastern Province of Saudi Arabia. *Journal of Family and Community Medicine, 21*(1), 39-47. doi:10.4103/2230-8229.128778

Manzuma B. M., Mbamali I., Stanley A. M. and Sani M. (2018): Carbon Dioxide Emissions from Energy use and Mitigation Potential of Household Behavioural Modifications in Kaduna Metropolis,

Nigeria. *Journal of Design and Built Environmen*t. Faculty of Built Environment, University of Malaya, Kuala Lumpur, Malaysia, Vol18 No. 1. pp 1 – 8.

Nazaroff, W. (2004). Indoor particle dynamics. *Indoor Air*(14), 175-183.

NESREA. (2014). *National Environmental Air Quality Control Regulations.* Lagos, Nigeria: The Federal Government Printer.

NPC. (2006). *Population. National Population Commission Census Report*. Retrieved May 22, 2012, from Nigerian Statistics Annual Report: http://www.nigerianstat.gov.ng/nbsapps/annual_reports/CHAPTER%202.pdf

Oberdorster, G. (2000). Pulmonary effects of inhaled ultrafine particles. *International Archives of Occupational and Environmental Health, 74*(1), 1-8.

OSHA. (2011). *Indoor air quality in commercial and institution buildings*. Retrieved from US department of labour, occupational safety and health administration: www.osha.gov

Schober, P., Boer, C. and Schwarte, L. (2018): Correlation Coefficients: Appropriate Use and Interpretation. *Anesthesia & Analgesia*: 126(5) p1763-1768. doi: 10.1213/ANE.0000000000002864

Schwartz, J., Samet, J., & Patz, J. (2014). Hospital Admissions for Heart Disease:The Effects of Temperature and Humidity. *Epidemiology, 15*(6), 755-761.

TekcoPlus. (2016). *TekcoPlus Carbon dioxide meter COTK-57.* Hong Kong.

EPA. (2015). *Sources of indoor air pollution-biological pollutants.* Washington, DC: US Environmental Protection Agency.

Wanner, H. (2013). Sources of pollution in indoor air. *IARC Scientific Publication, 109*, 19-30.

WHO. (2016). *WHO Guidelines for Indoor Air Quality: Selected Pollutants.* Copenhagen: World Health Organization.

Zahra, F. (2015). Health effects of air pollution: Empirical analysis for developing countries. *Atmospheric Pollution Research, 7*, 201-206. doi:10.1016/j.apr.2015.08.011

ASSESSMENT OF DEVELOPMENT CONTROL ACTIVITIES IN YENAGOA, BAYELSA STATE

Jacob Atser, Godknows E. Nathaniel and Ikurekong EE
Department of Urban and Regional Planning, University of Uyo
jacobatser@uniuyo.edu.ng; nathkemg@gmail.com

Abstract
This study assesses the activities of Bayelsa State Physical Planning and Development Board (BSPPDB) with a view to determining its level of performance, identify the types of contraventions and underlying factors, and the problems of BSPPDB in Yenagoa, The study area was delineated into 20 units along their native community boundaries. To obtain data needed for this study, 15 members of the management staff of BSPPDB were purposively selected for interview to obtain data relevant to assessing the activities of BSPPDB in Yenagoa. The baseline data also include data from official records of BSPPDB. The data types utilized include data on the number of plans approved over the years and number of demolitions carried out, data on types of contraventions, factors influencing contraventions and problems of the Board. Canonical correlation which is a general procedure for investigating the relationships between two sets of data, one comprising several Y variables and the other several X variables was utilized. In this study, the relationships between types of contraventions (y-variables) and the underlying factors (x-variables) were investigated. The results showed that between 2008 and 2022, the BSPPDB registered a total of 3285 plans for approval but only 1370 (41.70%) plans were given approval. In terms of the relationship between plans submitted and plans approved, the correlation coefficient value of .049 implies a no significant relationship and thus attests to the poor performance of the Board in approval of plans. Overall, the only significant canonical function, indicated r^2 type effect size of about .99985, which shows that the full model explained substantially about 99.99% of the variance shared between the types of contraventions and the underlying factors, thereby inferring that a statistically significant relationship exists between the variables set by evidence of statistical significance and effect sizes and that this relationship was largely captured by only the first function in the canonical model. On the basis of the findings, it is recommended that for improved performance in the activities by the BSPPDB, there is the need for the employment of professionally qualified Urban and Regional Planners in addition to the need for an adequate funding and provision for necessary working equipment for the staff.
Keywords: development, control, board, activities, performance

Introduction

The growth of a settlement into a city brings luxuries and opportunities which are not found in the rural areas (Makinde, 2012). These attractions generate influx of people into our cities which are usually not planned for; and they make a city to grow at a rate that is difficult to control. The state of the physical environment, according to Makinde (2012), particularly the conditions of the sub-urban centers, is a major source of concern to everyone in the built industry. This scenario is observed in most cities of the world. The failure of urban planning and development control has resulted in a huge deficit in building decent cities, which has led to the development of slums in a variety of contexts globally. According to (Ogundele *et al*. 2011), development control is the process of regulating any building or rebuilding operations in, on and under the land. The UN-Habitat (2013) identified some cities to have up to 80 per cent of their resident population living in unorganized slum settlements. It further asserted that up to fifty-five million new slum dwellers have been added to the global population since the year 2000. Slums are a clear manifestation of a poorly planned and managed urban sector and, in particular, an indication of a malfunctioning urban management system.

The concern for proper development control is more expressed in developing nations in sub-Saharan Africa like Nigeria (Yemi, 2004). It is even more disheartening when you consider the fact that the physical environment is consciously built by man. As such, it is expected that man should have taken more caution in building a decent and organized urban areas for his physical, social, economic and political activities. As it is well known, Nigeria is one of the most urbanizing countries in Africa. Many

of Nigeria's large towns grow at between 4 and 5 percent growth rate per annum despite the present economic recession. Much of this urban growth and development is taking place in the unplanned urban settings, resulting in substantial proportion of the population living in unplanned and un-serviced urban environments (omega 2002; Abdulazeez & Umar, 2017). This growth however, has been accompanied by enormous shortages in infrastructure to accommodate the influx. This is expressed in the form of deficiencies in housing, water supply, sewage, electricity, formal education, health facilities, transportation, and communication facilities. As the core of towns and cities become overcrowded, the uncontrolled and unplanned urban sprawl grows in leaps and bounds. The excessively high rate of the sprawl of the urban periphery is capable of impacting negatively on the environment. It could affect the aquifer, the ecosystem, pond life, wood, land, soil erosion, recreational facilities and ultimately, the health of the inhabitants (Oyeleye, 2013).

According to Ola (1977), the issue of controlling physical development in our urban settlements remains crucial to the health of our cities. For instance, the sitting of incompatible developments based either on the grounds of social, economic or political interventions is a serious threat, and it is very harmful to the co-existence of human and the other elements of the built environment. Development control, as it were, has always been the pivot on which town planning practitioners perfect the geometric drawing on the paper to the ground; through arts and science of planning, which attempt the ordering and arrangement of animate and inanimate objects to engender harmonious balances (Adeye, 2010). It suffices to say that without 'development control', the exercise of town planners as experts of spatial management will amount to nothing. This calls for the need to set up proper legal framework to enforce the control of urban development, which is the primary purpose of town planning.

The establishment of town planning institutions with legal framework to control development on the environment is mainly to ensure that developers strictly adhere to stipulated town planning regulations. This is to avoid the implications of haphazard development for the health of inhabitants, their comfort, convenience, safety, functionality and aesthetics. These can be achieved through the proper ordering of land uses by preparation of development plans and their implementation. This is a veritable tool of the development control machinery. In consonance with this line of reasoning, the United Nations traced most of the problems of urban land policies and land use control measures in developing countries to lack of clear cut policy on development, inadequacy of town and country planning laws and ineffective administrative frame work (United Nations, 2002). It is observed that where the appropriate administrative structures are not put in place to enforce development control, then landowners and estate developers will build anywhere and anyhow. Such development trend will continue to cause a chaotic and disorderly growth of the towns. They will encroach on adjourning properties, obstructing areas earmarked as right-of-ways, traffic flow, drainage channels, and penetration of the natural sunlight and issues of ventilation. Other outcomes include the obstruction of access of emergency responses of fire or ambulance services to affected buildings. Such will make it difficult to lay water mains, sewage lines, electricity cables, telephone cables and other infrastructures on the ground.

All these and probably more are the challenges suffered by the residents of Yenagoa, the Capital of Bayelsa State due to lack of proper development control. The Bayelsa State Physical Planning and Development Board (BSPPDB) was established to basically tackle all planning problems. The BSPPDB is saddled with the responsibility of preparing physical development plans, implementation of the plans, controlling the development and to ensure the proper use of land including control of bill-boards within urban areas of the State. Furthermore, it is charged to provide, manage and maintain public amenities including street furniture and equipment, open spaces and green areas; acting as the state coordinating agency of projects related to physical and environmental planning by providing the required infrastructure such as roads, drainages, water, electricity, and telephone facilities in all approved layout schemes; planning and carrying out of urban renewal programmes to upgrade the slum environment; upgrade quality of blighted parts of urban centres and preserving buildings and objects of historical and/or architectural interest.

The Bayelsa State Physical Planning and Development Law, 2015 established the existing Bayelsa State Physical Planning and Development Board (BSPPDB). The Board was established to improve on the

activities of the defunct Capital City Development Authority (CCDA). The study area is of great social and economic significance in terms of industrial jobs creation directly related to oil production and indirectly in terms of commercial, transport, banking and insurance opportunities. The phenomenal growth of the town due to the aforementioned potentials has led to the growing demand for housing and infrastructural development to the extent that if effective development control is not in place, there is the likelihood of the emergence of disorderly development. The emergence of disorderly developments has the potentials of bringing about sub-standard physical development that would cause problems like flooding, pollution, and overcrowding and traffic congestion. This existence of disorderly development in any town points to the ineffectiveness of development control operations. It is based on this perspective, that this research is poised to examine the activities of development control operations in Yenagoa.

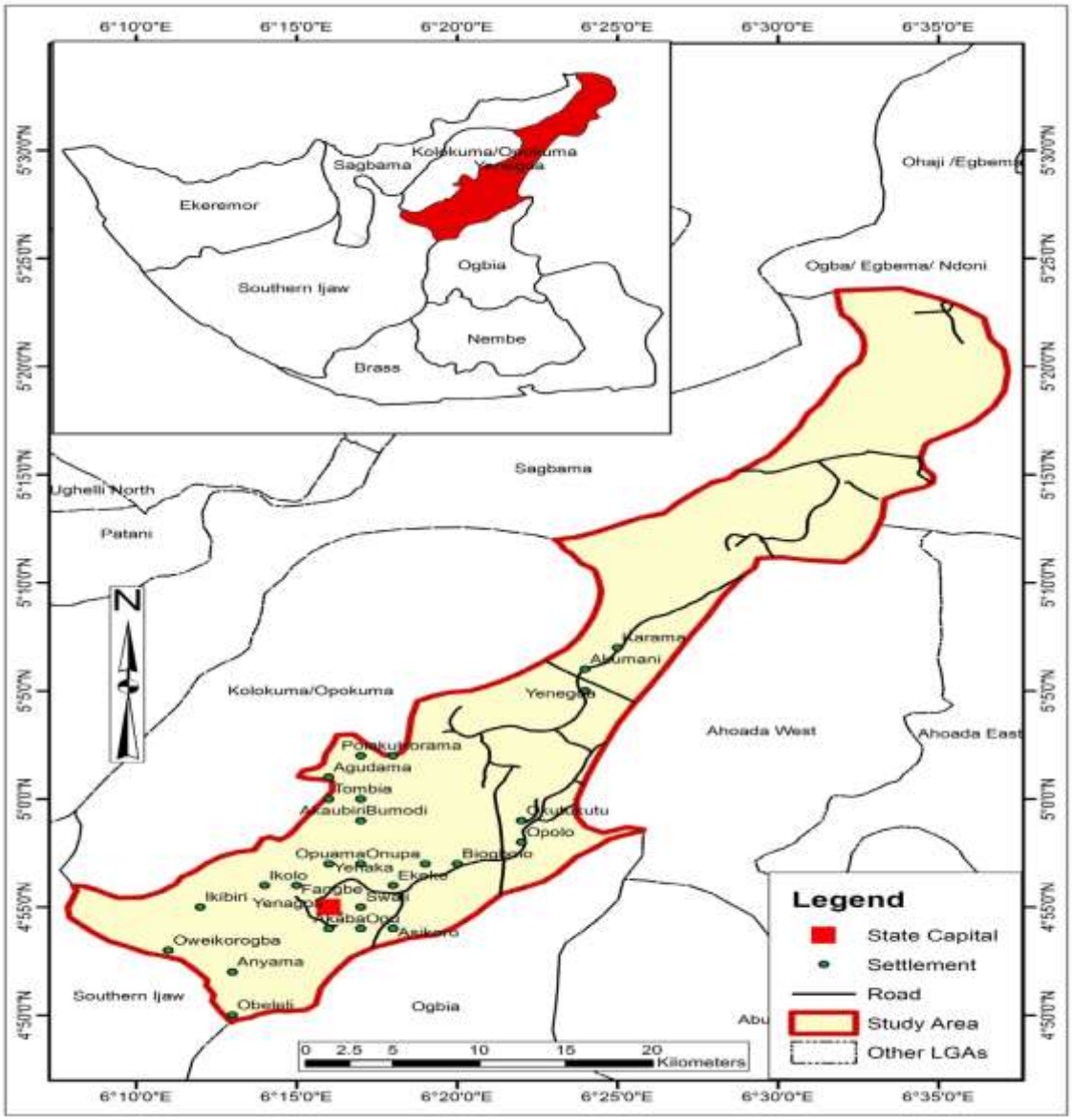
One major concern in development discourse is the performance of government agencies especially in developing countries like Nigeria. BSPPDB has been in existence since 2015, and its evaluation has become expedient considering the fact that one major urban development problem in Yenagoa revolves around the activities of development control. However, the extent and the level of performance of BSPPDB have not been clearly audited to provide a springboard to gauge its level of efficiency and effectiveness. Such an assessment has become timely going by the fact that most government agencies are mere shadows of themselves with little or no results to match financial commitment. Besides, knowledge about underlying factors of contraventions and problems encountered by BSPPDB would help to strengthen and reposition BSPPDB for improved service delivery. This is the thrust of this study with the aim of assessing the activities of BSPPDB since inception. Thus the objectives are to;

i. examine the performance of the BSPPDB in Yenagoa,
ii. assess the activities of the BSPPDB in Yenagoa,
iii. determine the relationship between types of contraventions and the underlying factors in Yenagoa,
iv. examine the problems of BSPPDB

This research work focuses on the assessment of the activities BSPPDB. The assessment centres on the 15-year operations of the Board, ranging from 2008-2022 in Yenagoa, the capital of Bayelsa State. This period overlaps into the period when development control activities were performed by the defunct Capital City Development Authority (CCDA). For the purposes of this study, the performance rating is based on developers' perception of the activities of the BSPPDB in Yenagoa as well as the number of approved development plans. Therefore, the number of the approved building plans in this study duration will stand out to be the surrogate. Surrogates have been used in similar works done. In most of such assessments, the researchers used number of sites visited as a surrogate to measure development control activities of the development agencies (Ugwu, 2014).

Study Area and Methodology

In this section, efforts are made to critically examine the attributes of the study area to provide a better understanding of the location, and environmental settings as well as the population and socio-economic activities of the area. All these elements are believed to affect urban development and the activities of the Board. Yenagoa, which is the study area, is the capital of Bayelsa State and it lies between the geographical coordinates of 4^{o} 50' and 5^{o} 24' North of the Equator, and 5^{o} 00' and 6^{o} 37' East of the Greenwich Meridian (Fig.1). Yenagoa Local Government area has an area of 706 km^2 and a population of 352,285 persons during the 2006 National Population and Housing Census. According to Alagoa *et al*. (2009) Bayelsa State is one of the least developed states in Nigeria, such that even Yenagoa, the State capital still lacks basic infrastructure. There is poor implementation of physical development plans, and the control of buildings in remote parts of the city is difficult due to lack of access roads. Electricity is not stable and most of the electrification works are haphazardly done. Most residents do not have access to pipe-borne water and health cum educational facilities is also grossly inadequate in relation to the population in the city. The study area is the entire Yenagoa metropolis and this area was further subdivided into 20 units. These units are traditionally delineated along their native community boundaries. They include Azikoro, Swali, Ovom, Yenagoa, Onopa, Amarata, Okaka/Ekeki, Yenizue-Epie, Kpansia, Yenizue-Gene, Biogbolo, Opolo, Okutukutu, Etegwe, Edepie, Akenpai, Agudama, Akenfa, Yenigwe and Igbogene.



Source: Office of the Surveyor-General, Bayelsa State, 2022
Figure 1: Yenagoa on the Administrative Map of Bayelsa State

To obtain data needed for this study, 15 members of the management staff of BSPPDB were purposively selected to obtain data relevant to assessing the activities of BSPPDB in Yenagoa. The baseline data for the study area was obtained through questionnaire administration and data from official records. The data types utilized include data on the number of plans approved over the years and number of demolitions carried out, data on types of contraventions, factors influencing contraventions and problems of the Board. These data were used to assess the performance of the BSPPDB. Canonical correlation which is a general procedure for investigating the relationships between two sets of data, one comprising several Y variables and the other several X variables was utilized. In this study, the relationships between types of contraventions (y-variables) and factors influencing contraventions (x-variables) were investigated.

Data Presentation and Analysis

With respect to building plans registration and approval by the BSPPDB (Table 1), the total number of approved building plans was sought. From the period covering 2008 to 2022, it was discovered that the BSPPDB registered a total of 3285 plans for approval within a period of 15 years. Out of the total registered plans, 1370 plans were issued approval and the rest (1915 plans) were pending approval. This

indicates that for the last 15 years, the BSPPDB has approved 41.70 % of the building plans registered by it, while 58.30% of the registered building plans wait approvals. In terms of the relationship between plans submitted and plans approved, the correlation coefficient value of .049 implies a no significant relationship and thus attests to the poor performance of the Board in approval of plans. However, the high rate of building plans pending approval was attributed to a combination of factors ranging from poor staffing, poor working tools, poor work environment, and bureaucratic cumbersomeness to inability to pay building plans approval/sundry fees as well as faulty design specifications and lack of complementary documents.

Table 1: **Registration and Approval of Building Plans by BSPPDB**

S/N	Year	Plans Submitted	Plans Approved	Plans Pending Approval
1.	2008	631	63	568
2.	2009	262	151	111
3.	2010	171	87	84
4.	2011	172	104	68
5.	2012	220	58	162
6.	2013	217	129	88
7.	2014	209	128	81
8.	2015	167	81	86
9.	2016	125	64	61
10.	2017	121	61	60
11	2018	182	72	110
12	2019	177	94	83
13	2020	245	121	124
14	2021	288	102	186
15	2022	98	55	43
	TOTAL	**3285**	**1370**	**1915**

Source: BSPPDB (2023)

A comprehensive survey on other development control activities in Yenagoa was carried out in this study and the result is presented in Table 2. A total of 105 illegal structures were demolished in the study area within a period of 15 years given an average of 7 structures per year. This is quite low and thus implies that though there were more contraventions (232), not all were demolished. Besides, not all contraventions amount to demolition as most contraventions are due to non adherence to registration formalities. The Board was also involved in public awareness campaigns on development control operational activities and undertook urban renewal schemes.

Table 2: Other Major Activities of the BSPPDB

S/no.	**Communities**	**A**	**B**	**C**	**D**	**E**
1.	Azikoro	5	4	63	15	1
2.	Swali	1	3	51	10	1
3.	Ovom	2	4	86	12	1
4.	Yenagoa	3	12	50	22	4
5.	Onopa	8	4	58	7	2
6.	Amarata	7	12	75	9	1
7.	Ekeki/Okaka	9	12	87	14	1
8.	Yenizue-epie	8	12	81	10	1
9.	Kpansia	5	3	64	11	1
10.	Yenizue-gene	6	3	61	9	1
11.	Biogbolo	5	4	72	8	1
12.	Opolo	4	4	84	12	2
13.	Okutukutu	7	4	75	13	1
14.	Etegwe	1	3	62	6	1
15.	Edepie	5	3	55	10	1
16.	Akenpai	9	4	82	15	2

17.	Agudama	7	4	74	13	2
18.	Akenfa	2	3	53	11	2
19.	Yenigwe	6	3	58	9	2
20.	Igbogene	5	12	79	16	2
	Total	**105**	**113**	**1370**	**232**	**30**

A=number of illegal structures demolished; B=number of public awareness campaigns/year; C=Number of building plans approved; D=Number of contraventions; E=Number of urban renewal schemes

The problems affecting the performance of the Board were examined among the staff of the Board as shown in Table 3. Inadequate funding ranked first among the problems, followed by poor work environment and poor staffing. Improved performance of the Board implies addressing these problems on a sustainable basis.

Table 3: Major Problems of BSPPDB

	Problems of BSPPDB	Res	SA	A	N	D	SD	Sum	Mean	Rank
1	Poor staffing	15	8	2	3	2	0	61	4.07	3rd
2	Inadequate funding	15	12	2	1	0	0	71	4.73	1st
3	Poor operational working tools	15	7	3	3	1	1	59	3.93	4th
4	Poor work environment	15	10	2	1	2	0	65	4.33	2nd
5	Bureaucratic bottleneck	15	6	4	1	2	2	55	3.67	5th
6	Inflexible standards	15	5	3	2	3	2	51	3.40	6th
7	Unrealistic planning goals	15	3	2	3	3	4	42	2.80	7th

SA=strongly agree(5); A=agree(4); N=neutral(3); D=disagree(2); SD=strongly disagree(1)

In this study, the different types of contraventions were investigated alongside the factors influencing contraventions in Yenagoa and data is shown in Table 4. The relationship between the types of contraventions (y) and the underlying factors (x) were investigated using the Canonical Correlation Analysis (CCA). In situations like this where there are multiple dependent and independent variables; canonical correlation analysis is the most appropriate multivariate technique. The Canonical correlation is the simple Pearson Correlation between two sets of variables linearly combined. Thus, using CCA, the relationships between the five dependent variables and the four independent variables were examined simultaneously.

Table 4: Types of contraventions (Y) and underlying factors (X) Variables

Communities	Y1	Y2	Y3	Y4	Y5	X1	X2	X3	X4
Azikoro	1	3	1	3	2	1	2	3	3
Swali	2	2	2	3	3	2	2	3	3
Ovom	3	1	3	3	3	3	3	2	3
Yenagoa	3	3	3	3	3	3	3	3	3
Onopa	2	3	2	2	2	2	3	2	2
Amarata	2	2	1	2	2	1	2	2	2
Ekeki/Okaka	2	2	1	1	1	2	1	1	1
Yenizue-epie	1	1	2	2	1	1	1	1	1
Kpansia	3	3	1	1	3	3	3	2	3
Yenizue-gene	2	1	2	1	2	2	1	1	2
Biogbolo	1	2	2	1	2	1	2	1	2
Opolo	2	1	2	2	3	2	3	2	2
Okutukutu	2	3	3	2	2	1	3	2	2
Etegwe	1	2	2	1	1	2	1	1	1
Edepie	1	1	1	1	2	1	2	1	1

Akenpai	1	1	2	1	1	1	2	1	1
Agudama	3	2	1	2	2	2	1	2	2
Akenfa	2	2	2	1	2	1	2	1	2
Yenigwe	2	1	2	1	1	1	1	1	1
Igbogene	3	3	2	2	1	3	3	2	2

Y1= No Building Plan; *Y2*= Over Building of Plot; *Y3*= Blockage of Access Road/drainage; *Y4*= Encroachment (violation of building line/ setbacks); *Y5*= Violation of zoning; *X1*= Political interference; *X2*= Developers' ignorance; *X3*= Level of poverty; *X4*= Level of literacy.

The use of linear equations in canonical analysis is directly analogous to the use of linear equations in the more familiar multiple regressions in which beta (β) weights are multiplied with observed scores and then summed to yield synthetic predicted scores. Using standardized weights analogous to beta weights, CCA creates two linear equations, where one is for the independent variables and the other is for the dependent variables. These equations then yield the two synthetic variables illustrated in Figure 2. The canonical functions extracted represent models that explain the pattern of linkages between the two sets of data as shown below.

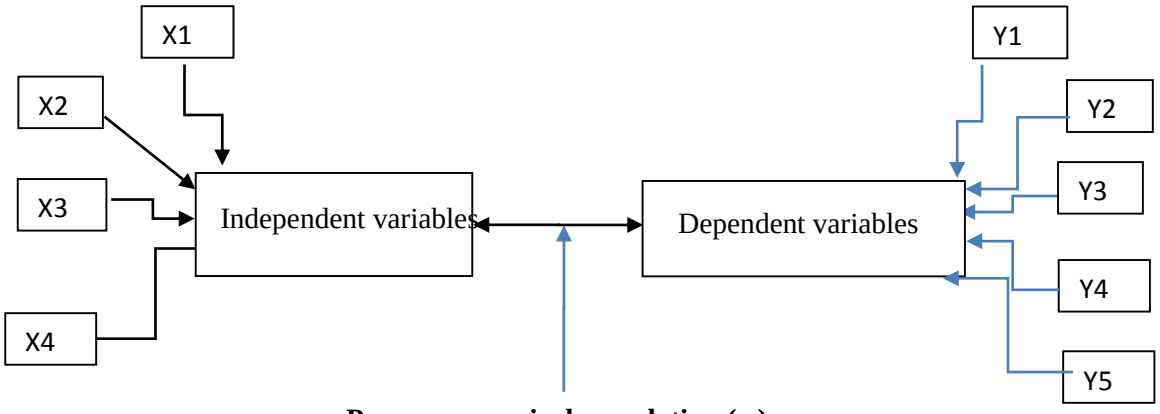


Figure 2: Dependent and independent sets of variables in canonical correlation analysis

From Table 5, the canonical correlation coefficient (r_c) which is the Pearson r relationship between the independent variables and the dependent variables on a given canonical function is indicated. Because of the scaling created by the standardized weights in the linear equations, this value cannot be negative and only ranges from 0 to 1. The r_c is directly analogous to the multiple R in regression. Table 5 also shows the squared canonical correlation (r_c^2) which is the simple square of the canonical correlation coefficient. It represents the proportion of variance shared by the two sets of variables. Because the variables represent the observed independent and dependent variables, the r_c indicates the amount of shared variance between the variable sets. A canonical function is a set of standardized canonical coefficients (from two linear equations) for the observed independent and dependent variables. There are as many functions as there are variables in the smaller variable set; which in this case, four functions are extracted.

Table 5: Test of Null Hypothesis

Eigen values of Inv(E)*H = CanRsq/(1-CanRsq)						Test of H0: The canonical correlations in the current row and all that follow are zero					r_c	r_c^2
Functions	Eigen value	Difference	Proportion	Cumulative	%	Likelihood Ratio	Approx F Value	Num DF	Den DF	Pr> F		
1	2084.9687	2083.7369	0.9992	0.9992	99.92	0.00015031	24.73	20	37.433	<.0001	0.999760	0.999521
2	1.2318	0.8087	0.0006	0.9998	99.98	0.31353206	1.47	12	32.041	0.1872	0.742920	0.551931
3	0.4231	0.4189	0.0002	1.0000	100.00	0.69973979	0.85	6	26	0.5458	0.545262	0.297311
4	0.0042		0.0000	1.0000	100.00	0.99580257	0.03	2	14	0.9710	0.064788	0.004197

Each function is uncorrelated to every other function, which means that each set of independent variables and dependent variables are perfectly uncorrelated with all other independent and dependent variables from other functions. Because of this orthogonality (uncorrelated nature), the functions are analogous to components in a principal component analysis.

Table 6: The Canonical Structure

Correlations Between types of contraventions and their Canonical Variables				
	W1	W2	W3	W4
Y1	0.8797	0.2500	-0.2015	0.3000
Y2	0.7533	-0.2244	0.0552	-0.3086
Y3	0.9479	0.0517	-0.0045	-0.1583
Y4	0.2589	-0.6226	0.5176	0.3842
Y5	0.9160	0.0946	0.3532	-0.1340
Correlations Between underlying factors and their Canonical Variables				
	V1	V2	V3	V4
X1	0.9411	-0.2117	-0.1349	-0.2268
X2	0.8906	0.0893	-0.4457	-0.0112
X3	0.5982	-0.3739	-0.2602	0.6593
X4	0.9413	0.0176	0.3308	-0.0650

Table 7: Canonical Solution for the First Function

	r_s	r_s^2	h^2	Total %
Y1	0.8797	0.7739	77.39	
Y2	0.7533	0.5675	56.75	
Y3	0.9479	0.8985	89.85	
Y4	0.2589	0.0670	6.70	
Y5	0.9160	0.8391	83.91	
% variance	.6292			62.92
Redundancy	.8352			83.52
X1	0.9411	0.8857	88.57	
X2	0.8906	0.7932	79.32	
X3	0.5982	0.3578	35.78	
X4	0.9413	0.8861	88.61	
% variance	.7307			73.07
Redundancy	.8543			85.43

Key: r_s = Structure coefficients; r_s^2 = squared structure coefficient;

Table 7 shows the structure coefficients (r_s) which are the bivariate correlations between the observed variables and the synthetic variables. In CCA, it is the Pearson r between an observed variable (a predictor variable) and the canonical function scores for the variable's set (the synthetic variable created from all the predictor variables via the linear equation). Because structure coefficients are simply Pearson r statistics, they may range from –1 to +1 inclusive. They inform interpretation by helping to define the structure of the synthetic variable, that is, what observed variables can be useful in creating the synthetic variable, and therefore, may be useful in the model. These coefficients are similar to those structure coefficients found in a factor analysis structure matrix or in a multiple regression as the correlation between a predictor and the predicted y- scores (Courville & Thompson, 2001). Squared canonical structure coefficients (r_s^2) are the square of the structure coefficients. This statistic is similar to any other r^2 -type effect size and indicates the proportion of variance an observed variable linearly shares with the synthetic variable generated from the observed set of variables. A canonical communality coefficient (h^2) is the proportion of variance in each variable that is explained by the

complete canonical solution or at least across all the canonical functions that are interpreted. It is computed simply as the sum of the (r^2) across all functions that are interpreted for a given analysis. This statistic informs one about how useful the observed variable was for the entire analysis. Table 7 shows the structure coefficients and communality coefficients derived from the analysis while Figure 3 shows the loadings and canonical correlations for the first function extracted.

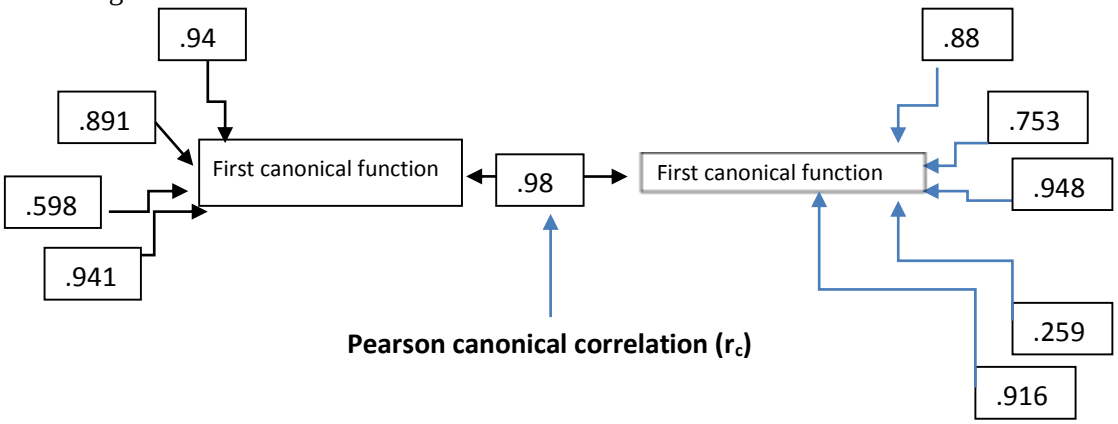


Fig 3: Loadings and canonical correlation for the first canonical function shown in Table 7.

How much variance does the first canonical function extract from the variables on its own side is shown in the output in Table 7. The redundancy in canonical function is the percentage of variance it extracts from its own set of variables multiplied by the squared canonical correlation for the pair. From Table 7, the first canonical function extracted each 62.92% of variance from the types of contravention variables and 73.07% of variance from the underlying factors. Redundancies for the canonical function are found in Table 7. The first function accounted for .8352 (83.52%) of the variance in the types of contraventions, while the underlying factors accounted for .8543(85.43%). The Canonical Correlation Analysis (CCA) conducted used the four underlying factors as predictors of five types of contraventions to evaluate the multivariate shared relationship between the two variable sets. The analysis yielded four functions with squared canonical correlations (Table 5). When interpreting results in the context of general linear model, the analysis is approached hierarchically, by asking two questions: *Does any effect occur and if so, where does the effect originates?* There is need to determine whether the canonical model sufficiently captures the relationship between the independent and dependent variable sets to warrant interpretation. That is, does any significant relationship exist between the variables? This is examined using the most common approaches of statistical significance testing and effect size interpretation as shown in Table 8.

Table 8: Multivariate Statistics and F Approximations S=4 M=0 N=4.5

Statistic	Value	F - value	Num df	Den df	Pr >F
Wilks' Lambda	0.0001503	24.73	20	37.433	<.0001
Pillai's Trace	1.8529593	2.42	20	56.0	.0050
Hotelling-Lawley Trace	2086.6278	1058.22	20	17.75	<.0001
Roy's Greatest Root	2084.9687	5837.91	5	14	<.0001

Firstly, there is need to evaluate the full canonical model. Table 8 presents four ways to evaluate the statistical significance with multivariate tests. These test statistics are for the full model, which means they evaluate the shared variance between the independent and dependent variables across all of the canonical functions. Each test statistic can be converted to the more familiar *F* statistic, which can then be evaluated for statistical significance. Of importance, because each of the four methods is based on somewhat different theoretical frameworks, each can lead to different conclusions. By far the most common method used is Wilks' Lambda (λ) , as it tends to have the most general applicability. In this

study, the full model was statistically significant, with a Wilks' Lambda (λ) value of 0.00015, $F(20, 37.43) = 24.73$, $p < .0001$. Here the table presents the p value of <.0001 which is less than .05 and thus, implies that statistical significance exists in the relationship between types of contraventions and the underlying factors. However, this statistical significance test tells us absolutely nothing about the magnitude of the relationship, which is one limitation of such tests. Therefore, it is important to interpret effect size indexes and perhaps other information, such as confidence intervals alongside p values to determine the practical significance of the study outcomes. Wilks' Lambda, λ has a useful property that helps inform this issue because it represents something of an inverse effect size or the amount of variance not shared between the variable sets. Therefore, by taking $1 - \lambda$ (1-0.00015= 0.99985), an overall effect for the full model emerged. This effect statistic can be interpreted just like the multiple R^2 in regression as the proportion of variance shared between the variable sets across all functions. Overall, the only significant canonical function, indicated r^2 type effect size of about .99985, which shows that the full model explained substantially about 99.99%, of the variance shared between the types of contraventions and the underlying factors. Therefore, it can be inferred that a statistically significant relationship exists between the variables set by evidence of statistical significance and effect sizes and that this relationship was largely captured by only the first function in the canonical model. Thus, the first function has demonstrated theoretically consistent relationships among all of the variables that contributed usefully to the function.

Conclusion and Recommendations

The importance of development control in physical planning cannot be over-emphasized. In fact, its benefits are enormous and can only be comprehended and appreciated if fully embraced in our towns and cities. It is obvious from the findings that the performance of BSPPDB in terms of plans approval was quite low. However, statistical significance was established between types of contraventions and underlying factors. The knowledge about these factors is a step towards providing an enduring solution to development contraventions in our cities. The BSPPDB undertakes several activities in Yenagoa metropolis but their performance is plague by several problems which should be addressed. There should be a deliberate effort to prepare an up-to-date land use plan as well as strategic plans for various utilities and facilities. This will effectively guide the growth and development of the city in a manner that will prevent encroachment into easement lines that are reserved for public utilities as well as violation of building lines and setbacks. In order to check the problems of lack of building setbacks and the blockage of access roads, detailed layout plans of various districts of the city should be extracted from the master plan. In this process, building lines and standardized setbacks from the center of various categories of roads should be defined, and such information should be made available to the public. The operational jurisdiction of the BSPPDB should be streamlined to cover only the Yenagoa metropolis. From the study, it is obvious that the Board lacks the capacity to perform development control activities to cover the entire Bayelsa State. Local Government headquarters and other major towns should be under the control of Local Planning Authorities. For the effectiveness and efficiency of the development control activities by the BSPPDB, there is the need for the employment of professionally qualified Urban and Regional Planners. This should be done in addition to the need for an adequate funding in order to provide necessary working equipment for the staff. Public awareness campaigns on the activities of the BSPPDB should be intensified so as to enlighten the general public on the importance of urban development planning and control. A sustainable public enlightenment programme will sensitize the residents, developers and other stakeholders in the building industry on the need for development control. Such awareness would facilitate a proactive public participation by either implicitly or explicitly involving the public to monitor the built environment.

References

Abdulazeez, U. R. and Umar, A. A. (2017). Enforcing Building Setbacks as a Viable Strategy for an Emerging City. *Path of Science Journal*. 3(6):21-27.

Adeye, L. A. (2010). Understanding Development Control of Settlement. DismetesTimade Ventures Ile-Ife.

Alagoa, E. J.; Tamuno, T. N. and Clark, J. P. (2009). The Izon of the Niger Delta. Onyoma Research Publications, Port Harcourt.

Bayelsa State Physical Planning and Development Law, 2015.

Courville, T. and Thompson, (2001). Use of Structural Coefficients in Published Multiple Regression Articles: B is not enough. *Educational and Psychological Measurements*, 61:229-248.

Makinde, O. O. (2012). Housing: Control City Slums: Case Study of Ibadan, *Journal of Environment and Earth Science*, 2: 9-

Ogundele, F. O.; Ayo, O.; Odewumi, S. G. and Aigbe, G. O. (2011). *Challenges and Prospects of Physical Development Control: A Case Study of Festac Town*, Lagos, Nigeria: African Journal of Political Science and International Relations. 5(4):174-178

Ola, C. S.(1977). *Town and Country Planning Law in Nigeria*. Ibadan University Press.

Omeje, M. C. (2002). "*Development Control as a Tool of Physical Planning in Abuja*", A Case Study of Wuse District; Unpublished BURP Dissertation, Department of Urban and Regional Planning, UNEC.

Oyeleye, O. I. (2013). Challenges of Urbanization and Urban Growth in Nigeria. *American Journal of Sustainable Cities and Society*, 1(2): 34-56

Ugwu. L. (2014). *An Evaluation Of The Performance Of The Rural Development Agencies In Enugu State*. An unpublished Ph.D thesis, Department of Urban & Regional Planning, Enugu State University of Science and Technology, Enugu

UN-Habitat (2013). A *report on State of the World's Cities*, 2012/2013.

United Nations Economic and Social Council (2002). *Economic Commission For Africa, Third meeting of the Committee on Sustainable Development*, 7- 10 October 2002, Addis Ababa, Ethiopia, reports on selected themes in land development in Africa

Yemi,O.(2004). *Problems and Prospects of Development Control*. Paper presented at the 2004 Annual Delegates Conference of the Nigerian Bar Association Holding at the International Conference Centre Abuja; 22 - 27 August.

INVESTIGATING CHALLENGES ENCOUNTERED IN THE APPLICATION OF LESSON LEARNED PRACTICE IN PUBLIC PARTNERSHIP PROJECTS (PPP) IN KANO STATE

Gali A. Zarewa, *PhD Q/Surveying, MSc. Project Mgt, BSc. Q/Surveying, MNIQS, RQS*
Department of Quantity Surveying, Faculty of Earth and Environmental Sciences, Bayero University Kano.
galzarewa.qs@buk.edu.ng; galizrw@gmail.com

Abstract
Application of Lessons Learned Practice (LLP) in Public Private Partnership (PPP) projects will explore structure of the arrangement; issues and impediments that confronted members of the PPP teams and how they addressed them to move the projects forward; present the results of using a particular PPP approach; lessons learned from procuring the project under a PPP arrangement; and conclusions about the project. The foregoing discourse have made LLP in PPP projects very important and necessitated the need to address any challenge that can hamper effective LLP in the projects. This study investigated challenges encountered in the conduct of LPP in two PPP projects through literature study and case studies after which findings were discussed and analysed. The study discovered that most of the participants were not aware of the LLP concept, there was no framework or template to guide the conduct of LLP and no resources or staff were specifically assigned for the conduct of LLP as a result of which the concept was incorrectly and incompletely conducted. The study recommended the training of prospective PPP participants in LLP, development of a framework and/or template to guide the conduct of LPP and making LLP in PPP projects mandatory by the Infrastructure Concession and Regulatory Commission (ICRC) for all parties to PPP projects.
Keywords: Lessons Learned Practice; Public Private Partnership

Introduction

The use Public Private Partnership (PPP) by governments as a procurement strategy for the provision of infrastructure is increasing worldwide due to increasing demand for such services by the populace and limited funds available to the governments. Public Private Partnership (PPP) is a partnership between the public and private sectors for the purpose of delivering a project or service that were hitherto solely provided by the public sector. European Commission (2003) has defined PPP as an agreement between two or more parties who have agreed to work cooperatively towards shared and/or compatible objectives and in which there is shared authority and responsibility, joint investment of resources, shared liability or risks taking and ideally mutual benefits. PPPs provide government agencies with opportunities to deliver infrastructure facilities using private sector resources without necessarily committing public debt or equity. Several infrastructure projects have been and are being procured through PPP by federal and many state governments in Nigeria.

If properly formulated and managed, a PPP can provide a number of benefits to the public sector such as: alleviating the financial burden on the public sector due to rising infrastructure development costs; allowing risks to be transferred from the public to the private sector; and increasing the "value for money" spent for infrastructure services by providing more efficient, lower cost, and reliable services (Kwak, *et al* 2009). Dolol and Jin (2009) have discovered that efficient project delivery under PPP was complex due to presence of uncertainty and risks affecting virtually all aspect of project life cycle; complex project composition and associated functional integration; complex network of relationship among various stakeholders; multi project operation and increased public participation.

The increasing complexity, duration and multitude of parties involved in a typical PPP procurement process, have made several studies to stress the importance of proactive, concentrative and systematic capture of project knowledge through the use of formal lessons learned practices (Ibrahim & Price, 2005; Ibrahim, 2007). This discovery implied that any challenge encountered in the conduct of LLP in PPP projects will impact the projects' performance because the purpose of LLP is to share and use knowledge derived from experience to promote the recurrence of desirable outcomes and preclude the recurrence of undesirable outcomes (Department of Health & Human Services, United State of America, 2006). Graham and Thomas, (2006) and Aecom Consult (2007) were of the opinion that application of LLP in PPP projects will explore the structure of the arrangement; the issues and impediments that confronted members of the PPP teams and how they addressed them to move the projects forward; present the results of using a particular PPP approach; lessons learned from procuring

the project under a PPP arrangement; and conclusions about the project. The foregoing discourse have made LLP in PPP projects very important and necessitated the need to address any challenge that can hamper effective LLP in the projects.

Lessons Learned Practice (LLP) is an aspect of knowledge management (KM) because it encourages the capture and dissemination of knowledge gained on past projects to enhance learning and future performance (Carillo, 2010). It involves processes necessary for the identification, capture, documentation, storage and dissemination of lessons learned. Definition of LLP by Fong and Yip (2006) in their studies which referred to LLP as the activities, people, and products that support the identification, collection, verification, documentation, storage, sharing, dissemination and reuse of verified lessons learned in organizations was adopted for the purpose of conducting this study.

It has however been observed that despite the continuous use of PPP to procure projects in Nigeria and the importance of LLP to the success of PPP projects described above, numerous challenges are being encountered in the conduct of LLP in the course of the projects' (PPP) delivery and not much efforts have been made in identifying and addressing these challenges. It is in the light of the foregoing that this study investigated the challenges encountered in the delivery of PPP projects in Kano State, Nigeria.

Methodology

The study was conducted using a combination of extensive literature review on PPP and LLP and case studies of two PPP projects in Kano State. A case study approach was adopted because literature on the study area is still largely underdeveloped and little information exists on the subject in line with the discovery of Yin (2003) and Barley (2006) who found out case study was among the best research method in such circumstances. Provision of opportunities for exploring additional questions by the act of investigating a topic in detail offered by the method as discovered by Hancock and Algozzine (2006) was another reason case study was used. Explanatory case studies of two PPP projects (38no. Blocks of 100 Room Students Hostel and an Economic City) were conducted. Each case study started with collection of basic information on the project and issues related to LLPs from primary project information sources such as files, reports, minutes of meetings, agreements and memorandum of understanding. Follow up semi-structured interviews were then held with representatives of both the clients and concessionaires/developers and other project participants on the conduct of LLPs in the course of the projects delivery and the challenges encountered while conducting the LLP.

Case Studies Findings and Analysis

Two PPP projects were investigated to find out challenges encountered in the course of conducting lessons learned practice (LLP) therein and recommend how to address the challenges in order to improve effectiveness of LLP in the procurement of PPP projects. The case studies centered mainly on how LLP was conducted in the projects, challenges encountered in the conduct of LLP and how to address the challenges. Findings from the investigations and their analysis were as given below.

Project A: Construction of Students Hostels

The project was part of the Nigerian Universities Students' Hostels Development Scheme on BOT basis initiated by the Federal Government of Nigeria in 2002 under the coordination of Federal Ministry of Housing and Urban Development, Abuja. It involved the provision of 38no 100 room hostel blocks under a tripartite agreement between a University in Kano (referred to as the promoter in the agreement), 38no Developers and two financiers (referred to as sponsors). The project was intended to be procured under Build- Operate and Transfer (BOT) basis but was abandoned at various stages of completion due to the inability of the financiers to provide funding.

Appraisal of LLPs in Project A

A startling discovery from preliminary discussions with some of this project's participants on LLPs revealed that they have never heard of the LLP concept before as result of which they were enlightened on the concept. The participants immediately appreciated the desirability and usefulness of the application of LLPs in the procurement of all projects.

Further investigations on the conduct of LLP in the project found out that the conduct of LLPs was not formalised in the project and the only activity related to the eleven basic LL activities undertaken in the project was the preparation of periodic progress reports indicating successes recorded and

challenges/problems encountered for presentation to monthly review meetings. Even this activity was not undertaken in accordance with the LLP concept which, Milton (2009) said, required capture of successes and reasons for the successes; challenges/problems encountered and causes of the challenges; how the challenges/problems were handled and their impact on the project. This discovery which clearly indicated that only a part of one of the eleven basic LL activities was conducted showed that the level of LLP in the project was very low as it was just 9.1%.

The study further revealed that no resources and staff were specifically allocated and/or assigned for conducting LLP while leadership of the project procurement was very indifferent to the conduct of LLP. It was also discovered that there was no framework or template that could have guided the conduct of LLP in the course of the project delivery. Documentation and storage of information which are part of effective LLP were also found to be discouraging.

Challenges Encountered in the Conduct of LLPs in the Project

A summary of the major challenges identified as constraints to the conduct of LLPs in the project included among others the following: -

i. Lack of adequate knowledge on the LLPs concept and its importance to effective project delivery by most of the project participants;
ii. Lack of a framework and/or template for the conduct of LLPs;
iii. Leadership's indifference to the conduct of LLPs in projects;
iv. Lack of organisational culture that encourages knowledge management; and
v. Non allocation of resources specifically for the conduct of LLPs.
vi. Discouraging documentation and storage of information

Project B: establishment of an Economic City

The Project, which is still ongoing, was initiated to be procured under a PPP arrangement between Kano State government, a Developer and a consortium of foreign and domestic banks.

Facilities expected to be provided by the project when completed included among others a five-star hotel; a world trade centre; a retail market consisting of 5,500 lock-up shops; trailer park; administration building; police station; banks; etc. The declaration of the major financier of the project as a distressed bank by the Central Bank of Nigeria about ten years ago led to the abandonment of the project but work at the project has resumed recently after an agreement with a new investor.

Appraisal of LLPs in Project B

The project participants consulted during the study said that they were not aware of LLPs as a result of which they were enlightened before proceeding with further investigations. The enlightenment made them to appreciate the usefulness of the application of LLP in the enhancement of effective delivery of PPP and other projects. They also admitted that many issues in the project would have been handled more effectively if they were aware of the LLP concept before. The concept could have guided them on how to documented knowledge gained from experience to address the issues, they added.

Investigations after the enlightenment found out that the conduct of LLPs was not formalised in the project in addition to indicating that no LLP related activity was undertaken in the course of the project procurement except documentation of progress and challenges/problems encountered for presentation to site meetings. Even this documentation that can be said to be part of LL capture and documentation process was not done in compliance with the LLP concept which stipulates that capture of challenges/problems should include causes of the challenges; how they were handled and their impact on the project. This finding which indicated that only one out of the eleven basic LL activities was observed, has, like in the hostel project, showed that the level of LLP in project was dismally low. Other discoveries made in the previously discussed project such as non- allocation of resources and assignment of staff for the conduct of LLP, leadership indifference to LLP, lack of framework or template to guide the conduct of LLP and discouraging documentation and storage of information system were also found in this project.

Results and Discussions

Challenges Discovered to have been encountered in the Conduct of LLPs in the Projects

Different challenges were discovered to have impacted the conduct of LLP in the projects. A summary of the major challenges identified as constraints to the conduct of LLPs in the two projects is given here under

1. Lack of adequate knowledge in the LLP concept and its importance to effective project delivery by most of the project participants. Most of project participants knew very little about the LLP concept, processes associated with it and its influence on project performance.
2. Lack of a framework and/or template to guide the conduct of LLP
3. Indifference of the project executing organisations' leadership to LLP
4. Lack of formalization of LLP in both projects
5. Non allocation of resources and assignment of staff specifically for the conduct of LLPs by the projects executing organisations.
6. Lack of organisational culture that encourages knowledge management.
7. Lack of arrangement for knowledge management by the projects executing organisations.
8. Poor organisational culture of the project executing companies.and
9. Discouraging documentation and information storage systems

The above findings clearly indicated that incorrect and incomplete LLPs were conducted in the procurement of the projects which might have impacted their performance negatively. This is because Fong and Yip, (2006) have discovered that incorrect and incomplete LLPs resulted in missing the benefits of proper sharing, capture and reuse of knowledge which minimises the risks of reinventing the wheel, repeating costly mistakes and missing many other benefits by the project participants. The conduct of incomplete LLP occasioned by the identified challenges has also, according to, Aecom Consult (2007) deprived them of the opportunity to explore how issues and impediments that confronted other parties that executed a project under a PPP arrangement and how they addressed them to move the project forward with a view to learning how to handle similar situations in their project. The project participants have, in the views of Department of Health & Human Services, United State of America, (2006), lost the opportunity to share and use knowledge derived from experience to promote the recurrence of desirable outcomes and preclude the recurrence of undesirable outcomes in the studied and other projects procurement by not conducting incorrect and incomplete LLPs. The project participants themselves admitted that many issues in the project would have been handled more effectively if they were aware of the LLP concept before because the concept could have guided them on how to document knowledge gained from experience to address the issues.

Failure of the two projects to achieve their expected goals and objectives at the expected time could partly be attributed to the incorrect and incomplete conduct of LLPs in the projects because Midha, (2005) and Symonds (2011) have found out that if lessons were genuinely learned from various experiences and/or past projects, then the same mistakes would not be repeated in different projects. Information gathered through LLPs could have informed the participants what others did to develop and implement PPP projects, noting both the opportunities and challenges encountered in the execution of the projects..

Suggestions on how best to conduct LLPs in PPP projects in Nigeria

The project participants offered the under listed suggestions on how best to conduct LLP in PPP projects.

1. Conduct of LLP in PPP project should be made mandatory
2. Development of a framework and/or template to guide relevant stakeholders on the capture, usage, storage and dissemination of Lessons Learned (LL)
3. Project staff should be trained on LLP
4. Organisations involved in the execution of PPP project should allocate resources and assign staff specifically for the conduct of LLP
5. PPP project participants should mandatorily review the entire project and produce a LL report at the close of their project and
6. The Infrastructure Concession and Regulatory Commission (ICRC) should make all PPP projects executors to submit lessons learned reports to it at the close of their projects,

Conclusions and Recommendations

This study which investigated challenges encountered in the conduct of LLPs in PPP projects in Nigeria was apt and timely in view of the continuous adoption of PPP as a procurement method for the execution of infrastructural projects in Nigeria. The study discovered that there was no framework and/or standard template for the conduct of LLPs in the projects and conduct of LLPs was not formalised in any of the projects while none of the organizations that participated in the projects has a KM strategy for the capture, storage, application, reuse and dissemination of project knowledge such as LL. The challenges discovered in these projects may not be similar to LLP challenges in PPP projects in other part of the country but the findings may still be useful to parties wishing to procure projects through PPP in other locations.

The study recommends that a framework and/or standard template for the conduct of LLP should be developed by relevant stakeholders while PPP participating organisations should be encouraged to develop and use Knowledge Management strategy supported by appropriate tools for effective capture, application and sharing of project knowledge including LL by ICRC and/or other relevant institutions.

References

Aecom Consult (2007). *Final Report on Case Studies on Transportation Public Private Partnership in the United States of America.* Office of Policy and Government Affairs, Federal Highway Administration (FHWA) – HPTS New Jersey Avenue, SE Washington, DC 20590 United States of America.

Barkley, D. L.(2006). The Value of Case Study Research on Rural Entrepreneurship: Useful Method? *Presented at the Joint ERS-RUPRI Conference, Exploring Rural Entrepreneurship: Imperatives and Opportunities for Research, Washington, DC, October 26-27, 2006.*

Carrilo, P. (2005). Lessons Learned Practices in the Engineering, Procurement and Construction Sector. *Engineering, Construction and Architectural Management Journal, Vol. 12, No. 3, 2005. Pp 236-250.*

Cools, M., Slagmulders, R. & Abbeele, A.V.D. (2011). Management Control In Inter Organizational Relationships: Lessons Learnt From Public-Private Partnerships. *Vlerick Leuven Gent Working Paper Series 2011/04. Vlerick Leuven Gent Management School, Netherlands.*

Davidson, J (2006) Finding the value in lessons learned. *Knowledge Management Review, 9(3), 6–7.*
Department of Health & Human Services, U. S. A. (2006). *Practice Guide on Lessons Learned.* Retrieved September 28th 2011 from http://www2.cdc.gov/cdc/library/practices_guides/...
European Commission (2003). Guidelines for Successful Public Private Partnerships

Fong, P.S.W. and Yip, J.C.H. (2006). An Investigative Study of Lessons Learned System in Construction Projects. *Journal for Education in the Built Environment, Vol.1, Issue 2, August, 2006 pp. 27-38.*

Goodman, J. L (2008). *Best Practices for Researching and Documenting Lessons Learned.* United Space Alliance Houston, Texas. Retrieved December 6th 2011 from klab.or/DE/lessonslearned/reports/cr-2008-214777.pd

Hancock, D.R. and Algozzine, B. (2006). *Doing Case Study Research.* tearchers College Press, 1234 Amsterdam Avenue, New York, NY 100227.

Ibrahim, A. D. (2007). The Development of Procurement Strategy for Primary Health Care Facilities in Nigeria. A Thesis submitted to Loughborough University in partial fulfillment for the award of degree of Doctor of Philosophy.

Ibrahim, A. D., Ali, A. A. and Haddary, G.Y.M. (2007) Financing Public Infrastructures Using Public Private Partnerships: Contractual and Tendering Arrangements For Build-Operate-Transfer (BOT); *Journal of Construction Management and Engineering, Volume 1, No 1, January, 2007. Department of Building, Faculty of Environmental Design, A.B.U. Zaria.*

Ibrahim, A.D. , Price A.D.F. and Dainting, A.R.J. (2006). An Analysis of Success Factors for PPP in Infrastructure Projects in Nigeria. *Journal of Construction Management 12(1) 2006.*

Ibrahim, A.D., Price A.D.F. and Dainting, A.R.J. (2006). The Analysis and Allocations of Risks in PPP Infrastructure Projects in Nigeria. *Journal of Financial Management of Property and Construction, Volume II, No.3, Pp149-163, December, 2006.*

Integrated Development Investment Services Ltd (2008). Kano Economic City: Africa's Biggest Economic City.

Midha, A. (2005). *How to Incorporate "Lessons Learned" for Sustained Process Improvements.* Retrieved December 12th 2011 from www.ditc.mil/nda/2005mmi/thursday/midha.pdf

Milton, N. (2009). *What is a Lesson Learned.* Knoco Stories. Retrieved December, 13th 2011 from http://www.nickmilton.com/2009/05/what-is-a-l-l

Mora, M. (2010). Quantitative Vs Qualitative Research – *When to Use Which.* Retrieved December, 18th 2011 from www.surveygizmo.com/.../quantitative-qualitative-research/-

Nielsen, D. (2010). *Improve Project Performance with Lessons Learned.* Ezine Articles Newsletter. Retrieved December 6th 2011 from http://ezinearticles.com/?/improve-performance-with-Lessons-Learned.

North Atlantic Treaty Organisation (2010). *NATO Lessons Learned Handbook (First Edition).* Joint Analysis and Lessons Learned Centre Lisbon, Portugal.

Project Management Questions (2010). *How to Write Lessons Learned Report for a Construction Project?R*retrieved December, 8th 2011 from http://www.projectmanagementquestions.com/2239/how-write-L-L-

Project Management Questions (2011). How to Capture Lessons Learned? Retrieved December, 8th 2011 from http://www.projectmanagementquestions.com/2239/how-to-capture-

Qualitative Research Guidelines Project (2008). *Semi Structured Interviews.* Robert Wood Johnson Foundation. Retrieved December, 20th 2011 from http://www.qualres.org/HowSemi-362g.html
Robert Wood Johnson Foundation (2008). *Qualitative Research Guidelines Project.* Princeton, NJ 08543.

Robinson, H, Carrillo, P, Anumba, C and Al-Ghassani, A (2005) Knowledge Management Practices in Large Construction Organisations. *Engineering, Construction and Architectural Management, 12(5), 431–45.*

Symonds, M. (2011). *How Lessons Learned Can Improve Project Processes.* Project Smart, United Kingdom. Retrieved September 28th 2011 from http://www.projectsmart.co.uk/how-lessons-learned-can-improve-project.

Tan, H.C., Carrillo, P.M., Anumba, C.J., Bouchlaghem, N.M., Kamara, J.M., and Udeaja, C.E. (2005) Approaches to the live capture and reuse of knowledge of construction projects, In: Ribeiro, F.L., Love, P.D.E., Davidson, C.H., Egbu, C.O. and Dimitrijevic, B. (eds.), *Proceedings of the CIB W102 Conference on Information and Knowledge in a Global Economy*, Lisbon, Portugal, 19-20 May, pp. 577-586.

United Nations Environment Program (2011). *Strategy For The Dissemination And Communication of Lessons Learned*. Executive Committee of the Multilateral Fund for the Implementation of the Montreal Protocol. Retrieved December 13th 2011 from www.multilateralfund,org/MeetingandDocument/.../64/.../6407.pdf

Washington State Department of Information Services (2011). *Conducting Lessons Learned Exercise.* Washington, United States of America. Retrieved October 1st, 2011 from http//isb.wa.gov/pmframework/projectclosure/lessons.

Yin, R.K.(2003). *Case Study Research: Design and Methods. Applied Social Research Methods Series.* Sage Publications, London.

COMPRESSIVE STRENGTH OF RECYCLED AGGREGATES CONCRETE CONTAINING SUGARCANE BAGGASSE ASH AS A BINDER

Mas'udu Mamman, Dauda Dahiru, Balele Isah Alhaji and Abdullahi Ibrahim Getso
Ahmadu Bello University. Zaria
08027912608
masudmamman@abu,edu.ng

ABSTRACT
Current trend in research is toward finding alternative material that will fully or partially replace aggregates. Recycled aggregates seem to be one of the viable options. However, concrete produced with recycled aggregates have some deficiencies such as low compressive strength and high water absorption among others. As such researchers have been making effort to find ways and means to improving the quality of recycled aggregate concrete (RAC). One of the viable ways is the use of pozzolanic materials. This study made the use of sugar cane bagasse ash (SCBA) to assess its impact towards improving the performance of RAC. In this work RCA were source from demolished concrete structure and processed. Concrete mixes were then produced whereby RCA were used to replace Granite coarse aggregates (GCA) at 10%, 20%, 30%, 40% and 50%. Also for all the mixes 10% of cement was replaced with SCBA. Concrete cubes were produced and tested at 7, 14, 28, 56 and 90 day for compressive strength. The compressive strength result indicates that when 10% of SCBA is used 10% to 40% of normal aggregates can be replaced with RCA. It was recommended SCBA has positive impact on the compressive strength of RAC.
Key words: *Aggregates, concrete, compressive strength, Recycle aggregates,*

INTRODUCTION

Aggregate cover at least three-quarter of the volume of concrete then its quality is of considerable importance in the production of concrete (Neville 2011). Aggregates are primarily used as an underlying material for foundations and pavements and as ingredients in Portland cement and asphalt concretes (Mamlouk & Zaniewski, 2006). As world population is increasing there is also high increase in construction activities which lead to high consumption of aggregates. Therefore, due to high consumption of natural aggregates across the globe it is imperative to source other materials to partially or fully replace this aggregate. Using Recycled aggregates is one of the ways to reduce overdependence on conventional aggregates. Recycled aggregate is the waste or demolished debris obtained from construction site or other natural materials that was previously used for other purposes and due to its capability in terms of strength and durability it also been recycled and re-used for the construction purposes (Safiuddina, Ubagaram, Rahmanb, Abdussalamb& Mohd, 2013). Recycled aggregate has disadvantage of absorbing more water than natural aggregate which can negatively affects the workability and hydration process as well as Strength and durability of concrete (Fathei, Mochamad, & Ir, 2015). Similarly, this problem might be aggravated by affecting the quality of concrete, reduces strength, increased porosity, increased shrinkage and internal cracking of the matrix due to inadequate bonding between cement and aggregate paste (Rahman, Islam & Abedin, 2012). Also despite the availability and advantages of (RCA) it was reported that concrete produced with them have lower compressive strength (Asad, Yongjae, Muhammad & Cheolwoo, 2018). Specifically inadequate bonding may negatively affects the performance of recycled aggregate concrete Therefore there is need to find solution to these problems. It was recommended that incorporation of materials that possess pozzolanic reaction might improve the strength and performance of Recycled aggregates concrete (Jagadesh, Ramachandramuthy & Murugesan, 2018).

Pozzolanic materials are siliceous or siliceous and aluminous materials, which in themselves possess little or no cementicious value, but will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide liberated on hydration, at ordinary temperature, to form compounds, possessing cementicious properties (Shetty, 2000). These pozzolanic materials are grouped into two that is Natural Pozzolans such as Clay and Shales, Opalinc Cherts, Diatomaceous Earth, Volcanic Tuffs and Pumicites. Artificial Pozzolans include Fly ash, Blast Furnace Slag, Silica Fume, Rice Husk ash, Sugacane bagasse ash, Metakaoline and Surkhi to mention a few. Sugar cane bagasse ash is a waste obtained from sugar and ethanol industry which causes environmental problems in the

factories (Biruk & Abebe, 2012). However, it was initially dispose in landfill or used as a fertilizer. But due to abundances and its pozzolanic characteristics it can be used as construction materials to improve concrete performance (Qing, Tao, San-Ji, Zhengxian & Nengsen, 2018). Sugarcane bagasse ash has improved performance in the production of concrete (Jijo & Pandian 2017). Since sugarcane bagasse ash possess pozzolanic reaction which involves consumption of $Ca(OH)_2$ not production of $Ca(OH)_2$(Shetty, 2000). Therefore, for optimal utilization of recycled aggregate improving the strength of concrete containing recycled aggregate is necessary.

Materials and Method

Materials

The materials used for this research include; Granite coarse aggregate, recycled coarse aggregate, fine aggregates, Portland Cement, sugarcane bagasse Ash (SCBA).

***Fine aggregate*:** It was sourced and kept in the Concrete Laboratory of the Department of Building, Ahmadu Bello University, Zaria prior to the commencement of the experiments.

Granite Coarse Aggregates (GCA): It was also sourced from Abdu Gwari quarry at Sbon Gari Zaria and sieved using 20mm BS sieved which conform to (BS EN 12620, 2013). Only 20mm maximum aggregate size was used for the study.

Recycled Coarse Aggregates (RCA): recycled coarse aggregate for this experiment was sourced from demolished building in Sabon Gari Market, Sabon Gari Local Government area of Kaduna State Nigeria. It was sourced in boulders form and crushed manually in the laboratory. Moreover, all deleterious materials of recycled aggregate were washed out and allow drying under sunlight. Thus this sample of recycled aggregate was sieved using 20mm sieved conform to BS EN 12620, (2013) to obatianed 20mm maximum sizes.

Sugarcane Bagasse ash (SCBA): Sugarcane Bagasse for this experiment was obtained from Danja Local Government area of Katsina State, Nigeria and prepared in the Concrete Laboratory of the Department of Building, Ahmadu Bello University, Zaria. The SCBA was obtained by burning at temperature of about 800^{o}C grinded and sieved using 45mm micro sieve as suggested by Abd, Zubair, Mohamed, & Bashar, (2014).

Water: The water for this laboratory experiment was tap water conforming to BS EN 1008, (2002) was obtained in the Department of Building Llaboratory of Ahmadu Bello University Zaria, Nigeria

Method

Sample Preparation: Nominal mix ratio of 1:2:4 was used for the production of concrete cubes. The percentage replacement of recycle aggregate to conventional aggregate was 0% 10%, 20%, 30%, 40% and 50% while Sugarcane Bagasse Ash (SCBA) replace 10% of Portland limestone cement during the experiments for each mix. All the samples were prepared in the laboratory. 100mm x 100mm x 100mm moulds was used for the production of concrete cubes.

Materials Testing

Particle size distribution: Sieve analysis of FA, GCA and RCA was carried out in accordance with the standard test procedure of (BS EN 12620, 2013). The result was also recorded and tabulated in Table 1, 2 and 3 respectively. Also the following properties of the materials were tasted specific gravity, moisture content, water absorption, Bulk Density, Aggregates Crushing Value, Aggregates Impact Value, Chemical Composition of SCBA

Chemical Composition of SCBA: The test was done at the Department of Chemical Engineering Ahmadu Bello University, Zaria and XRF technique was used for the analysis of chemical content present in the sample as shown in Table 7.

Concrete Testing

The fresh properties and hardened properties tests of the concrete were carried out in the laboratory of the Department of Building Ahmadu Bello University Zaria, Nigeria. The results are shown in Figure 1 and 2.

Fresh Properties of RAC: The slump test was carried out at each replacement level RAC in accordance with standard specification BS EN 12350-2, (2009).the result is shown in figure 1

Hardened Properties of RAC: The compressive strength of concrete cubes was determined using compressive strength testing machine in accordance with (BS EN 12390-3, 2019). A total of 90 cubes were tested and 3-samples each were crushed at 7, 14, 28, 56 and 90 days curing

Results, Analysis and Discussion

Properties of the Aggregates

Particle size distribution of fine Aggregates (FA): **S**ieved analysis was used for the particle size distribution analysis of the river sand used for the work. The result is presented in Table 1.

Table 1 Particle size distribution of Fine aggregates (FA)

Sieve sizes (mm)	Weight retained (g)	Weight passing (g)	% Retained	% Passing
4.75	43	957	4.30	95.70
2.36	110	847	11.00	84.70
1.00	304	543	30.40	54.30
0.60	142	401	14.20	40.10
0.30	358	43	35.80	4.30
0.15	26	17	2.60	1.70
Pan	17	0	1.70	0.00
Total	1000	----	100	-----

Table 1 shows the particle size distribution of fine aggregates. Based on the findings 1.70% was the silt contained of the aggregate and 95.70% of the fine aggregates pass through BS 4.75mm sieve while only 4.3% were retained. Therefore, this aggregate is classified as fine aggregate as stated in BSEN 12620 (2013). However, the particle size distribution of this aggregate fall within range of zone I of the fine aggregate grading classification of (IS:383, 1970). As such the aggregate is suitable for mixing and production of concrete.

Particle size distribution of Granite Coarse Aggregates (GCA): sieved analysis was used for the particle size distribution analysis of the *Granite Coarse Aggregates* used for the work. The result is presented in Table 2.

Table 2 Particle size distribution of Granite coarse aggregate (GCA)

Sieve sizes (mm)	Weight retained (g)	Weight passing (g)	% Retained	% Passing
20	34.0	1966	1.70	98.30
9.5	1473	493	73.65	24.65
4.75	465	28.0	23.25	1.40
2.36	22.0	6.00	1.10	1.10
1.00	2.00	4.00	0.10	0.10
0.60	1.00	3.00	0.05	0.05
0.30	1.50	1.50	0.08	0.08
0.15	0.50	1.00	0.03	0.05
Pan	1.00	0.00	0.05	0.00
Total	2000	----	100	-----

Table 2 shows the particle size distribution of granite coarse aggregates used. The results indicated that 0.05% was found to be the only silt contained in these aggregates and 98.30% pass through 20mm BS sieve. Therefore, this aggregate is termed as coarse aggregate as the percentage passing through 20mm BS sieve is the highest as suggested in BSEN 12620 (2013). Hence these aggregate is good for production of concrete as the percentages of silt and the particle size distribution of this aggregate fall within the range of nominal sizes coarse aggregates as specify in (IS:383, 1970).

Particle size distribution of Recycled Coarse Aggregates (RCA): sieved analysis was used for the particle size distribution analysis of the Recycled Coarse Aggregates used for the work. The result is presented in Table 3.

Table 3 Particle size distribution of RCA

Sieve sizes (mm)	Weight retained (g)	Weight passing (g)	% Retained	% Passing
20	24	1976	1.20	98.80
9.50	1884	92	94.20	4.60
4.75	74	18	3.70	0.90
2.36	4.0	14	0.20	0.70
1.00	4.0	10	0.20	0.50
0.60	2.0	8.0	0.10	0.40
0.30	4.0	4.0	0.20	0.20
0.15	1.0	3.0	0.10	0.15
Pan	3.0	0.0	0.15	0.00
Total	2000	----	100	-----

Table 3 shows the particle size distribution of Recycled Coarse aggregates. The results indicated that 0.15% was the silt presence in these aggregate and 98.80% pass through 20mm BS sieve and 0.15% retained. Therefore, this aggregate is termed as coarse aggregate as the percentage passing through 20mm BS sieve is the highest as suggested by BSEN 12620 (2013). Also this aggregate is good for mixing and production of concrete as the percentages of silt and the particle size distribution are within the range of graded nominal sizes aggregates (IS:383, 1970). It can be observed that recycled and granite coarse aggregate for this work have similar characteristics in terms of particles size distribution and silt content. Therefore RCA can replace GCA in the production of RAC.

***Physical properties of Fine aggregates*:** Specific gravity, water absorption and moisture content of the FA were tested and the result was presented on Table 4.

Table 4. Physical properties of Fine aggregates

Test	**FA**	BS812-2-1995 limit
Specific gravity	2.63	2.5-3.0
Water absorption (%)	2.86	0 – 3.0
Moisture content (%)	2.14	0 -2.3

Table 4 shows physical properties of fine aggregates and the result shows that specific gravity, water absorption and moisture content of fine aggregates satisfy the BS812-2-1995 requirements. Therefore, the satisfaction of these properties with standard shows that the fine aggregates is good for concrete work.

***Physical properties of the coarse aggregates*:** Specific gravity, water absorption and moisture content of the GCA and RCA were tested and the results were presented on Table 5.

Table 5 Physical properties of GCA and RCA

Test	**GCA**	**RCA**	**BS812-2-1995**
Specific gravity	2.50	2.52	2.5-3.0
Water absorption (%)	0.58	2.38	≤ 0.60
Moisture content (%)	0.60	2.10	≤ 2.0
Bulk Density (kg/m^3)	1537	1350	1200-1750

Table 5 shows the physical properties of GCA and RCA. The results indicate that both the GCA and RCA used in the study satisfied the BS812-2-1995 limits requirement. Comparatively RCA can be used

as coarse aggregates in the production of RAC based on these findings. However, water absorption of RCA was found to be 2.38 which is 1.76% higher than the standard requirement. Hence, using RCA can reduce workability of the concrete mix. This implies that concrete produced may experience inadequate bonding between the aggregate and binder paste.

***Mechanical properties of the coarse aggregates*:** The Aggregates Crushing Value and Aggregates Impact Value of the GCA and RCA ware tested and the results are presented on Table 6.

Table 6 Mechanical properties of GCA and RCA

Sample	Aggregate crushing value %	Aggregate impact value %	BS 882: 1992
GCA	26.50	18.16	<45
RCA	27.85	18.95	<45

Table 6 shows the mechanical properties of GCA and RCA. Thus the result from the finding shows that aggregate crushing value of GCA and RCA fall within the range of the standard requirement. Hence these aggregates have good for resistance to crushing and impact loading as such this will lead to the production of a good and durable concrete (BS 882: 1992).

Chemical composition of sugarcane bagasse ash (SCBA)

The chemical composition of SCBA was analyzed and the percentage compositions of the elements are presented on Table 7.

Table 7 Chemical Composition of Sugarcane Bagasse Ash (SCBA) Result

Element	Concentration
SiO_2	56.912%
K_2O	12.121%
M_gO	7.870%
P_2O_5	5.801%
Al_2O_3	4.966%
Cl	4.092%
C_aO	2.8727%
Fe_2O_3	1.6457%
SO_3	1.4956%

Table 7 shows the chemical composition of sugarcane bagasse ash use for this research with S_iO_2 having the highest concentration of 56.912%. Thus Al_2O_3 and Fe_2O_2 having 4.966% and 1.645% respectively. However, the summation of silicon, aluminum and iron was found to be 63.523% and this indicates that SCBA is class C pozzolans as suggested by (ASTMC 618). As class c pozzolans possess cementicious value when react with water. Hence, it can be used as a binder in the production of concrete.

Fresh Properties of RAC

Workability

Slump test was used to assess the workability of the concrete samples use for this research. The results were presented on figure 1.

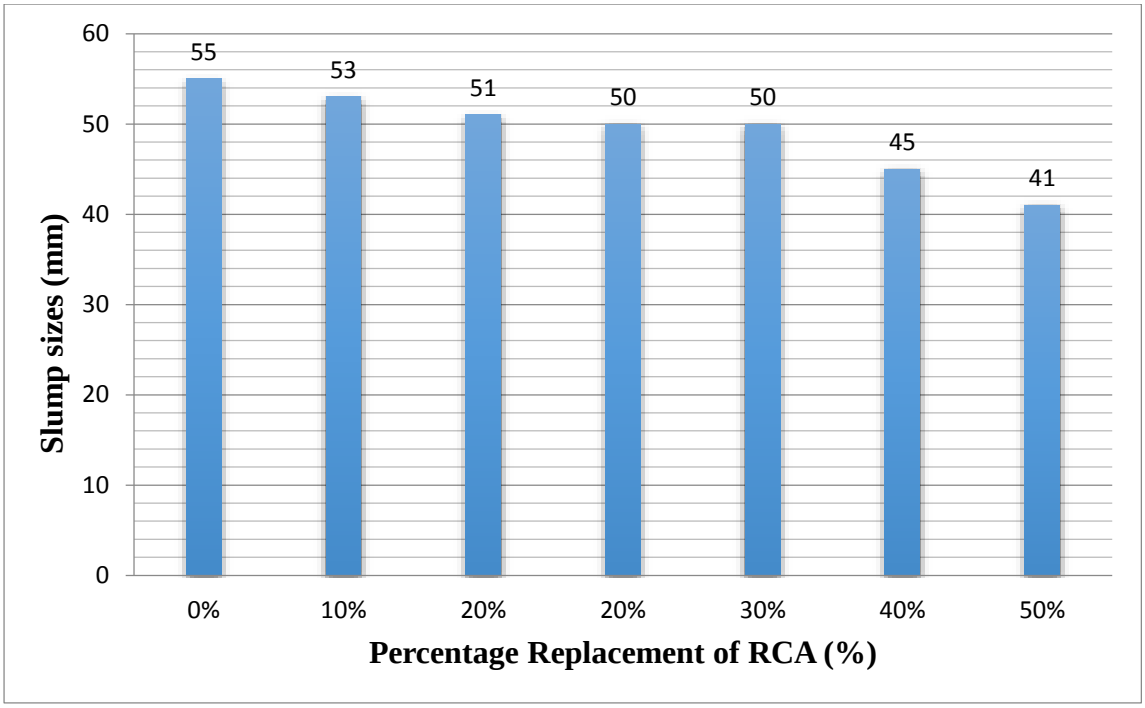


Figure 1 workability of RAC made with 10% SCBA

Figure 1 shows the effects of 10% partial replacement of cement with SCBA on the workability of concrete made with 0% to 50% RCA. It was observed that the degree of workability of RAC containing 10% SCBA for 10%, 20% and 30% replacement of GCA with RCA was found to be of medium workability as stated in (BS EN 12350-2, 2009). Hence, it will be suitable in the production of RAC for normal reinforcement section with vibration. But concrete made with 40% and 50% replacement fall within low workability range. Therefore, RAC produced with 40% and 50% can be used for mass concrete without vibration.

Mechanical properties of RAC

Compressive strength

Six different concrete samples were produced and tested for compressive strength at various curing periods. The results are presented in Figure 2.

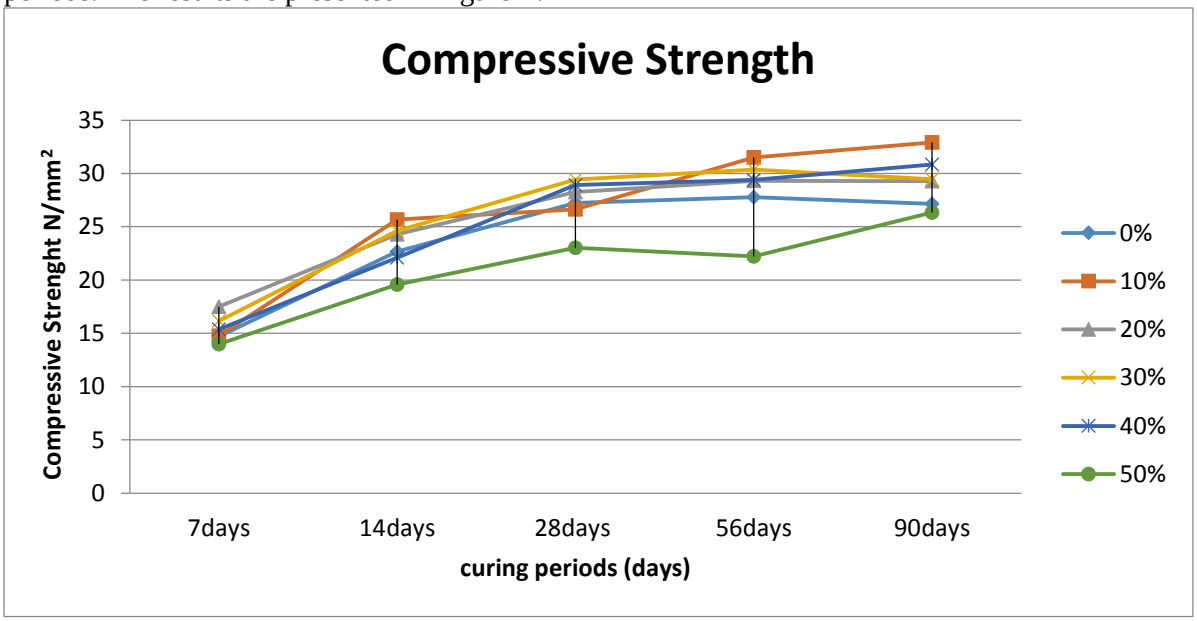


Figure 2 Compressive Strength of RAC made with 10% SCBA

Figure 2 shows the Compressive Strength of RAC made with 10% SCBA at 7, 14, 28, 56 and 90 days of curing with target strength of 30N/mm^2. The result indicated that at 28 days curing period the compressive strength of RAC is greater than that of control sample with 3.07%, 7.37%, 7.96% and 6.09% at 10%, 20%, 30% and 40% replacement respectively. But at 50% the compressive strength is 15.52% lower than the control sample. At 56 days curing periods the strength of RAC exceed the control sample with 13.3%, 5.58%, 9.29% and 5.86% for 10%, 20%, 30% and 40% replacement respectively while for 50% the strength drop with 20.02% lower than the control sample. Furthermore, at 90 days of curing there is also an increase in the strength of RAC compared to the control sample, with 10% replacement having the highest increment of 21.21% while 20% 30% and 40% replacement exceeded the control sample with 7.88%, 8.61% and 13.51% respectively. Thus, strength of RAC increases with longer curing period. Also strength of RAC decreases with increase in the Percentage of Recycled aggregate. Therefore, increase in strength was as result of pozzolanic reaction and fineness of SCBA that will fill up the voids between aggregates and binder paste thus making the concrete very homogenous in nature. This agrees with the findings of Sonali., Rakhi., & Swati., (2018).

Conclusions

This research evaluates the properties of recycled aggregate concrete containing sugarcane bagasse ash from the findings the following conclusions were drawn.

- **i.** The particle size distribution, specific gravity, moisture content and bulk density of recycled concrete aggregate satisfies the standard requirement of (BS EN 12620, 2013). However water absorption of RCA is higher than the specify value recommended by BS EN 12620, 2013.
- **ii.** The workability of RAC containing 10% SCBA was found to be medium for 10% - 30% replacement of GCA with RCA but for 40% - 50% was found to be low.
- iii. Replacing cement with 10% SCBA improve the compressive strength of RAC.

Recommendations

It is recommended that 40% partial substitute of GCA with RCA should be used in concrete containing SCBA.

REFERENCES

Abd, B. M., Zubair, I. S., Mohamed, H. I., & Bashar, S. (2014,). *Applied Mechanics and Materials*, 3.

ASTM C618 (2022).Standard Specification for coal Fly Ash and Raw or Calcinaed Natural Pozzolan Use in Concrete. *Americal Society forTesting and Material*

Biruk, H., & Abebe, D. (2012). Application of Sugercane Bagasse Ash as Partial Cement Replacement Materials. *Article in Jounal of Ethopian Engineers and Architects* , 1-67.

BS EN 1008. (2002). Mixin Water for Concrete Specification . *British Standard* .

BS 812-2 (1995) Testing Aggregates Methods for Determination of Density. *British Standard* .

BS EN 12350-2. (2009). Testing Fresh Concrete. *British Standard*.

BS EN 12390-3. (2019). Testing Hardened Concrete. Compressive strength of test specicimens. *British Standard*.

BS EN 12620. (2013). Aggragates for Concrete. *British Standard*.

Fathei, R., Mochamad, S., & Ir, s. (2015, january 1). Effect of Recycled Coarse Aggregate on Concrete

Properties. *International Journal of Innovative Research in Science, Engineering and Technology, Vol. 4,*, 19060-19068.

IS:383. (1970). specification of coarse and fine aggregate from Natural sources for concrete . *Bereau of Indian Standard* .

Jagadesh, p., Ramachandramuthy, A., & Murugesan, R. (2018). overview on the properties of sugercane bagasse ash (SCBA) as pozzolans. *Indian Journal of Geo Marine Science* , 1934-1945.

Jijo, J., & Pandian, P. (2017). A Short Review on the Valorisation of Sugarcane Bagasse Ash in the Manufacture of Stabilized/Sintered Earth Blocks and Tiles. *Advances in Materials Science and Engineering*, 1-16.

Mamlouk, M., & Zaniewski, J. (2006). *Materials for civil and construction engineers, second edition.* New Jersey: Pearson Education, Inc.

Neville, A. M. (2011). *Properties of Concrete.* Printed in Malaysia (CTP-VVP): Pearson Education Limited.

Qing, X., Tao, J., San-Ji, G., Zhengxian, Y., & Nengsen, W. (2018). Characteristics and Applications of Sugar Cane Bagasse Ash Waste in Cementitious Materials. *materials (MDPI)*, 1-19.

Rahman, M. S., Islam, S. M., & Abedin, M. Z. (2012). EFFECT OF CURING METHODS ON COMPRESSIVE STRENGTH OF CONCRETE. *Article in Bangladesh Journal of Agricultural Research*, 71-76.

Safiuddina, M., Ubagaram, J. A., Rahmanb, M. M., Abdus Salamb, M., & Mohd, Z. J. (2013). Use of recycled concrete aggregate in concrete. *Journal of Civil Engineering and Management*, 1-35.

Shetty M.S. (2000). *Concrete Technology Theory and practice.* New Delhi: S. CHAND & COMPANY LTD.

Sonali., N., Rakhi., S., & Swati., B. (2018). Experimental Study on Use of Scba in Concrete by Partially Replacement of Cement. *The International Journal of Engineering and Science (IJES)*, 76-81.

EFFECT OF AGGREGATE SIZES ON THE STRENGTH OF CONCRETE

David I.A[1] , Gana D[2], Usman N.D[3] and Musa, J.[4]
[1]Department of Technology Education, Modibbo Adama University Yola, Nigeria[1]
[2]Department of Technology Education, Modibbo Adama University Yola, Nigeria[2]
[3]Department of Building, Modibbo Adama University Yola, Nigeria[3]
[4]Department of Building, Federal Polytechnic, Nasarawa, Nasarawa State, Nigeria.
Corresponding Author: napodanusman@gmail.com

Abstract
The purpose of this study was to investigate the effect of aggregate sizes on the strength of concrete. An experimental design was conducted for the study. The experiment had three treatments, which were the aggregate sizes (10mm, 15mm, and 20mm) and fine aggregate. A constant mix of 1:2:4 with a water/cement ratio of 0.5 was used throughout the experiment. Tests conducted include slump and compressive strength tests. Fresh concrete batches were formulated from each of the coarse aggregate sizes and the slump test was conducted to test for workability. Thirty cubes (150mm × 150mm) were cast from each batch and the compressive strength was determined using a concrete load testing machine (Pro-Ikon cube press) after 7 days, 14 days, and 28 days of curing. The results showed that workability (slump) increased with increasing aggregate sizes. The mean compressive strength for the 10mm, 15mm, and 20mm were 15.32N/mm^2, 18.21N/mm^2, and 19.51N/mm^2 after 7 days of curing, 17.74N/mm^2, 19.65N/mm^2, and 21.39N/mm^2 after 14 days of curing and 20.53N/mm^2, 21.86N/mm^2, and 25.26N/mm^2 after 28 days, respectively. The 10mm and 15mm and 20mm aggregate's compressive strengths were significant (P0.05; 0.00). It was concluded that concrete workability (slump) was directly proportional to the aggregate sizes. The mean concrete compressive strength increased with increasing aggregate sizes. It was recommended that batching and mixing of materials must be effectively monitored and supervised by professional engineers to ensure that the right quantity and sizes of materials are employed as this is a critical aspect of quality control.
Keywords: *Aggregates, Compressive Strength, Concrete Effect, Sizes and Workability.*

1.1 **Introduction**

Concrete as a construction material, is a composite mixture of aggregates and water bonded by a cementitious material. The quality of any concrete in construction is indicated by the quality of the components of the concrete. Concrete has been used in construction for many years since the discovery of cement in Oregon and is known to be, second to water, in use by man for ages [Neville, 2004]. Concrete, a mixture of sand, gravel (or granite), cement and water, produced in proportionate quantities has been of choice for all forms of construction, be it residential, industrial, agricultural, etc., because of its versatility and ease of construction.

Aggregates constitute about 50 to 60% of the concrete mix depending on the mix proportion used. The larger the aggregate percentage in concrete mix, the more it's contribution to the strength of the concrete [Waziri, Bukar & Gaji]. Aggregates are the most mined material in the world. They are a component of composite materials such as concrete and asphalt concrete. The aggregates are responsible for the unit weight, elastic modulus and dimensional stability of concrete because these properties depend on the physical characteristics (strength and bulk density) of the aggregate [Anonymous, 2012]

The compressive strength of concrete is one of the major properties that is considered in any construction [Hollaway, 2010]. This property can be affected by many factors including water to cement ratio, degree of compaction, and shape aggregate sizes. Aggregate gradation plays an important role in concrete mixing. Unsatisfactory gradation of aggregates leads to segregation of mortar from the coarse aggregates. In the same vein, internal bleeding, need for chemical admixtures to restore workability, excessive water uses as well as increased cement had adverse effect on the workability and the aggregate sizes [Loannides & Mills].

A number of concrete structures around the globe, cracks and lose stiffness when subjected to external load. Having premature deterioration of concrete is an international problem; the building industry needs to increase the load carrying capacity of structures by using concrete of high strength. In concrete structures, the mix proportion of the different components together with the aggregate type and sizes, determine the compressive strength of hard concrete. Larger aggregates need high volume of water on its mix, thus as the workability increases, so also the compressive strength of concrete. Hence, the study tends to assess the effects of aggregates sizes on the compressive strength and workability of concrete.

2.1 **Review of Related Literature**

[Akanu-Ibiam & Aniekan, 2021] carried a study on the effect of coarse aggregate sizes on the strength of concrete. Materials for their study were (water, fine and coarse aggregates and cement). Acceptability criteria for tests on basic materials for concreting were ascertain such as; water according to BS 2690 standard, Fine and coarse aggregates according to BS 812:1975, part 1 to 4 standard and Cement according to BS 12:1991. The acceptability criteria for testing fresh and hardened concrete such as Workability test (slump test in accordance with BS 1881:1983, Part 102) and Compressive strength test (cube test in accordance with BS 1881:1983. The specimen size for crushing strength was 150mm x 150mm x 150mm, cured and tested for 7, 14 and 28 days with concrete grade 20 of minimum compressive strength of 14 N/mm2 (mix ratio of 1:2:4). From the result gotten, the concrete strength of aggregate size of 20mm to 28mm after 28 days was higher than that of 13.2mm to 19mm and that of 3.35mm to 10 mm.

Similarly, [Richie & Effort, 2020] carried out a study on the effect of coarse aggregate sizes on the compressive strength of concrete to ascertain which aggregate size produce the optimum compressive strength that may guide Builders and engineers in the construction industry. Regression equations relating the compressive strength of concrete using various aggregate sizes as well as the curing duration, fine aggregate, cement and water/cement ratios were developed. The adequacy of the model was checked using the coefficient of determination (R^2). The results indicate that the 9.5 mm aggregate sized concrete had 35 N/mm2 as compressive strength for 28 days curing duration, while the 12.5 mm aggregate sized concrete had 24 N/mm2 as compressive strength for 28 days curing duration and the 19 mm aggregate sized concrete's compressive strength was 23 N/mm2 when cured for 28 days. The compressive strength of 9.5 mm aggregate sized concrete had an increase of 1.46% and 1.52% over the 12.5 mm and 19 mm aggregate sized concrete's compressive strength. The low coefficient of determination (R^2) of 0.1270 for 9.5 mm aggregate sized concrete, R2 of 0.1322 for 12.5 mm aggregate sized concrete and R^2 of 0.1243 for 19 mm aggregate sized concrete shows that the linear model could not predict the compressive strengths of the different aggregate sized concrete efficiently.

In the same vein, a study carried out by [Kumar & Abraham, 2020] on The grading of aggregates is an important factor in the preparation of concrete and its compression strength. This experimental investigation was conducted to find the impact of different aggregate sizes on the compressive strength of the concrete. The aggregates used in this experiment were 8 mm and 11.2 mm sizes. The concrete of M 25 grade and the water-cement ratio of 0.4 was used for this experiment. Tests were done on the fresh concrete and hardened concrete. The fresh batches of concrete prepared from each of the coarse aggregate sizes were collected, and the slump test for the collected batches was conducted to determine the workability. 24 concrete cubes of size 150 mm × 150 mm were cast and cured for 28 days. The cubes, after 28 days of curing, were tested to determine the compression strength of the concrete. The results showed that the workability of the concrete was directly proportional to the aggregate size. Also, the compressive strength increased with an increase in aggregate sizes.

Another study conducted by [Olumide, Olufunke, Emeka & Patrick, 2018] on the effect of aggregate size on the compressive strength of concrete. Two nominal mixes, 1:2:4 and 1:3:6 were used in the study. Concrete cubes were produced with 6, 10, 12.5, 20- and 25-mm aggregates for the two nominal mixes and were subjected to compressive strength test after curing for 7, 21, 28 and 56 days. It was found in the study that the strength development follows the same trend for both nominal mixes. Also, the results showed that the compressive strength increases with increasing aggregate size up to 12.5 mm, while the concrete produced using 20 mm had greater compressive strength than those produced using 25 mm aggregate. This established the importance of ensuring that the right aggregate size is used in the production of concrete. Therefore, it is recommended that careful attention must be paid to the sizes of aggregates used in the production of concrete for structural purposes.

A similar study conducted by [Bruce & Ndlangamandla, 2016] on Aggregate grading as an important element in concrete mixing and the resultant compression strength. The experiment was conducted to determine the effect of aggregate size on the compressive strength of concrete. The experiment had three treatments, which were the aggregate sizes (9.5 mm, 13.2 mm and 19.0 mm) and the control. A constant mix of 1:2:4 with a water/cement ratio of 0.5 was used throughout the experiment. Tests that were conducted included the slump and compressive strength tests. Fresh concrete batches were

formulated from each of the coarse aggregate sizes and the slump test was conducted to test for workability. Three cubes (150 mm × 150 mm) were cast from each batch and the compressive strength was determined using a concrete load testing machine (Pro-Ikon cube press) after 7 days curing. The results revealed that workability (slump) increased with increasing aggregate sizes. The concrete made from the 9.5 mm, 13.2 mm and 19.0 mm aggregate sizes had workability (slumps) of 10 mm, 13.5 mm and 20 mm, respectively. The mean compressive strength for the 9.5 mm, 13.2 mm, and 19 mm were 15.34 N/mm^2 18.61 N/mm^2 and 19.48 N/mm^2 respectively. The 9.5 mm and 19.0 mm aggregates had compressive strengths that were significantly different (P0.05; 0.585). It was concluded that concrete workability (slump) was directly proportional to aggregate sizes. So also the mean concrete compressive strength increased with increasing aggregates sizes.

3. Materials and Method

3.1 Research Design

The research was true experiment design with three treatments including the control and three replications per treatment. Concrete mixtures of different aggregate sizes were used as treatments. The first, second and third treatments, is the coarse aggregate sizes of 10mm, 15mm and 20mm (control), respectively. The constituents that were used to formulate the concrete mixes are, Portland cement, river sand as fines and crush stone as coarse aggregates. A constant mix proportion of 1:2:4 and a constant water to cement (w/c) ratio of 0.5 was used throughout the experiment.

3.2 Area of the Study

The area of the study is Adamawa State, Nigeria. Adamawa is a state in northeastern Nigeria, whose capital and largest city is Yola. With 36,917 km² landscape, is bordered on the North and Northwest by Borno and Gombe states, on the West and Southwest by Taraba state, and on the Southeast and East by Cameroon. With coordinates of 9.3265° N, 12.3984° E

3.3 Description of Materials and Sourcing

Cement: Commercially available Ordinary Portland Cement was used for this purpose. This cement has a specific gravity of 3.15. (Dangote Portland cement).

Aggregate: Three sizes of coarse aggregates; 10 mm, 15 mm and 20 mm was obtained from Triacta Quarrying Site. The fine aggregate is normal sand obtained from a borrow pit in Yola. Preliminary laboratory investigation was conducted to ascertain the suitability of using the aggregates for construction work.

Water: Potable drinking water obtained from Department of Building Laboratory, Modibbo Adama University, Yola was used for this work. The water was suitable for concrete work (BS 3148, 1980).

The equipment and materials that were used in this study include; metal cube mould (150 mm × 150 mm × 150 mm), spade, compacting rod, slump test cone, concrete load testing machine (cube press; Pro-Ikon).

3.4 Experimental Procedure

3.4.1 Concrete Moulding

The concrete was mixed manually on a clean concrete covered surface to avoid incorporation of debris and absorption of moisture by the surface. Since coarse aggregates is source already graded from the quarry site, only the fine aggregates were sieved using a 5 mm test sieve to remove debris and attain homogeneity of the particles. The sand and cement were mixed on a non-absorbent surface using a spade and the mixing was done until the mixture is thoroughly blended and is of uniform colour. Then the coarse aggregates were added and mixed with the cement and sand made earlier until they were thoroughly distributed on the batch. A mound was opened from the top of the prepared mixture (cement, sand and coarse aggregates) and water was added using a water to cement ratio of 0.5. A spade was used to thoroughly mix the concrete constituents by working from the sides towards the center until the desired mix is achieved.

3.4.2 Placing of Fresh Concrete in the Mould

Below are the processes that was followed in the filling of the mould with concrete.

The moulds were cleaned and rubbed with condemned oil.

The moulds were filled in layers of approximately 50mm thick.

Each layer was compacted with 25 blows of tamping rod.
The top surface was leveled and smoothened with a trowel.

3.4.3 **Curing**

Concrete curing was done by covering the specimen with a plastic sheet under shade, while in the concrete moulds for the first 24 hours after moulding. The cube moulds were then carefully removed and the cubes was immersed in clean water for a period of 6 days. This was done for 7 days, 14 days and 28 days of concrete curing.

3.5 **Test Conducted**

3.5.1 Slump Test

The workability of concrete was measured by the concrete slump test. A simplistic measure of the plasticity of a fresh batch of concrete following the ASTMC 143 test standards was made.
The slump was measured by filling "ABRAMS Cone" with a sample of fresh batch of concrete. The cone was placed with the wide end down onto a level, non-absorptive surface. It was then filled, with each layer tampered with a steel rod to consolidate the layer in 25 numbers of times. The cone was carefully lifted and the enclosed material slumps a certain amount due to gravity. The slump was measured with a rule calibrated in mm and the values were recorded. The difference in level between the height of the mould and that of the subsided concrete was measured and this gave the measure of the slump. The three types of slump obtained in a slump test were true slump, shear slump and collapse and they are shown in Figure 1.

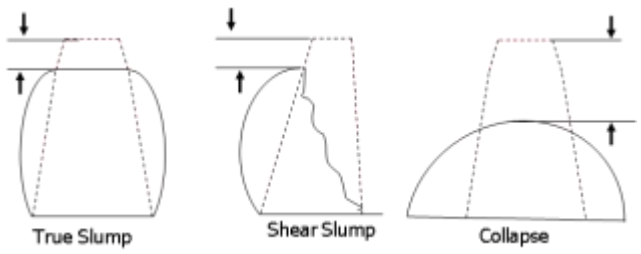


Figure 1: Types of Slump

3.5.2 ***Compressive Strength Test***

The concrete cubes were weighed using a beam balance prior to testing and the mass was recorded against the cube reference code. All the concrete cubes were tested on the same day using a concrete crusher. The compressive strength was calculated using equation 1.

$$\sigma_c = \frac{F}{A}$$

σ_c - Compressive strength (N/mm^2)
F - Failure load (N)
A - Area of bed-face (mm^2)

4. **Results**

4.1 Slump Test

Table 1: Concrete Slump Test Of Coarse Aggregate

S/N	Aggregate Size (mm)	Slump (mm)	Slump Test
1	10	10.0	True test
2	15	13.5	True test
3	20	20.0	True test

* w/c ratio was 0.5 and mix ratio was 1:2:4
Source: Laboratory Experiment, 2021

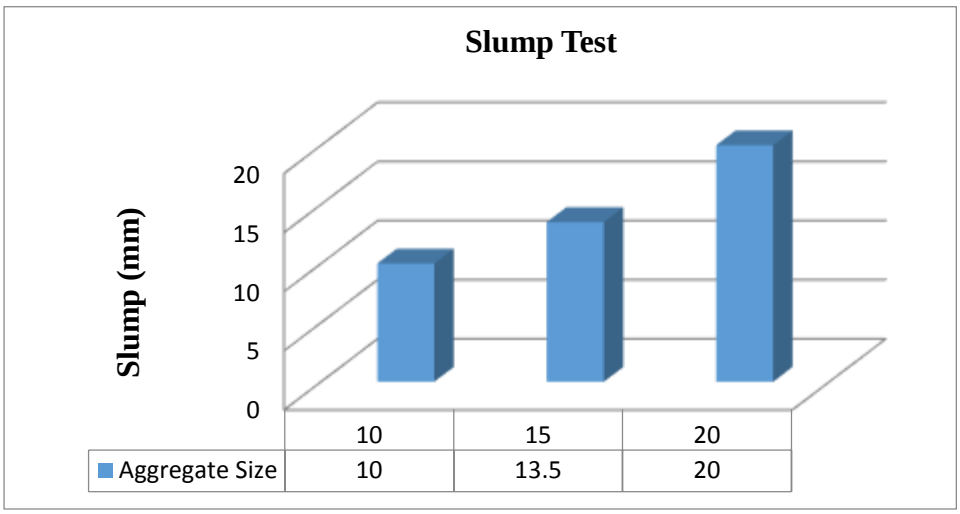


Figure 2: Slump Test Graph

The results in Table 1 and Figure 2 reflected that the workability (slump) for the 10 mm, 15 mm and 20 mm coarse aggregate sizes were 10 mm, 13.5 mm and 20 mm, respectively. It is worth noting that as the slump increases, so does the workability. However, this occurs while the compressive strength is increased, a condition driven by the water cement ratio (w/c).

Results indicated that the concrete workability (slump) was directly proportional to aggregate size, meaning that they both increased simultaneously. When all other factors (i.e. w/c ratio and mix proportion) remain constant an increase in coarse aggregate size led to an increase in workability. This occurs due to the increase in aggregate size, which results in smaller surface area being wetted. However, there are other constraints on the maximum aggregate sizes. Similarly, as the maximum aggregate size increases, so also the sizes the concrete increases.

4.2 Compressive Test

Table 2: Concrete Compressive Strength of 10 mm Aggregates after 7, 14 and 28 days of curing

S/N	Compressive Strength (N/mm^2)		
	After 7days	After 14 days	After 28 days
1	15.56	17.82	20.2
2	15.26	17.64	20.4
3	15.21	17.86	20.6
4	15.34	17.92	20.87
5	15.23	17.44	20.56
Mean	15.32	17.74	20.53

Source: Laboratory Experiment, 2021

The above table shows the concrete compressive strength of 10 mm aggregates after 7, 14 and 28 days of curing with mean of 15.32, 17.74 and 20.53 respectively.

Table 3: Concrete Compressive Strength of 15 mm Aggregates after 7, 14 and 28 days of curing

S/N	Compressive Strength (N/mm^2)		
	After 7days	After 14 days	After 28 days
1	18.62	19.2	21.89
2	17.8	19.7	21.56
3	19.4	19.84	21.82
4	18	19.86	22
5	17.23	19.65	22.04
Mean	18.21	19.65	21.86

Source: Laboratory Experiment, 2021

The above table shows the concrete compressive strength of 15 mm aggregates after 7, 14 and 28 days of curing with mean of 18.21, 19.65 and 21.86 respectively.

Table 4: Concrete Compressive Strength of 20 mm Aggregates after 7, 14 and 28 days of curing

S/N	Compressive Strength (N/mm^2)		
	After 7days	After 14 days	After 28 days
1	19.48	21.28	26.45
2	19.47	21.62	25.61
3	19.49	21.73	24.32
4	19.5	21.58	24.68
5	19.59	20.72	25.23
Mean	19.51	21.39	25.26

Source: Laboratory Experiment, 2021

Table 4 shows the concrete compressive strength of 20 mm aggregates after 7, 14 and 28 days of curing with mean of 19.51, 21.39 and 25.26 respectively.

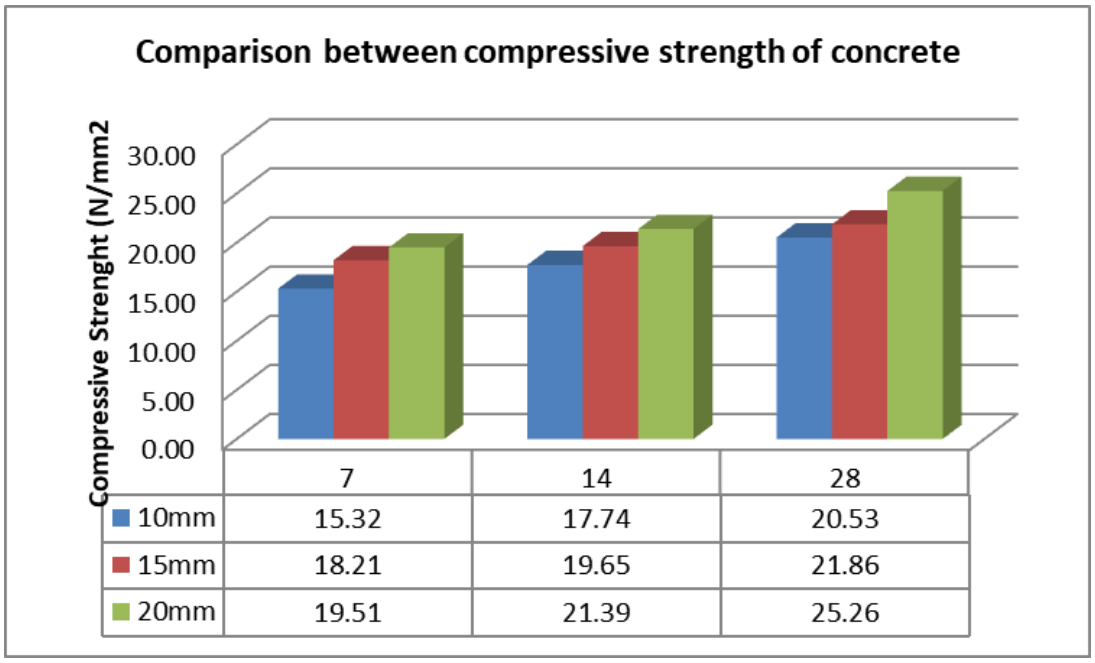


Figure 3: Graph of Mean of Compressive Strength of Concrete

Figure 3: Comparison between compressive strength of concrete with 10 mm, 15 mm and 20 mm coarse aggregates with respect to curing periods. It shows a comparison between compressive strength of concrete with 10 mm, 15 mm and 20 mm Coarse Aggregates with respect to curing periods. The compressive strengths were measured in 7, 14, and 28 days of curing respectively for all the specimens and compared. It was seen that, compared to 10 mm Coarse aggregates concrete in 7 days, the 20 mm coarse aggregates concrete compressive strength was increased by 7.90% being maximum and 15 mm coarse aggregates concrete compressive strength was also increased by 2.45%. In 14 days, the 20 mm coarse aggregates concrete compressive strength was increased by 6.21% being maximum and 15 mm coarse aggregates concrete compressive strength was also increased by 2.96%. Finally, in 28 days, the 20 mm coarse aggregates concrete compressive strength was increased by 6.99% being the maximum and as well, 15 mm coarse aggregates concrete compressive strength was increased by 5.03%.

Table 5: Regression Results

Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**T**	**Sig.**
		B	Std. Error	Beta		
1	(Constant)	-33.585	2.003		-16.765	.000
	CS7	.567	.216	.251	2.630	.023
	CS14	1.273	.341	.473	3.735	.003
	CS28	.604	.164	.302	3.676	.004
	F-value	298.35	P-value	0.00[a]		
	R^2	.988				
	R Adjusted	.985				

Table 5 shows that, a significant level of 0.023, less than 0.05, for the concrete strength after 7 days indicates a significant relationship with aggregates size. Secondly, concrete strength after 14 days shows a significance level of 0.003 indicating the existence of a significant relationship. This means that Null hypothesis was rejected. Moving the third hypothesis shows that as the workability increases, so also the strength of concrete increases after 28 days. This indicates a significance level of 0.004, which is less than 0.05, showing a significant relationship between the concrete strength after 28 days and the aggregates sizes. The results indicated that larger sized coarse aggregates yielded higher compressive strength than smaller sized aggregates. R-square value is 0.988, which indicates that 98.8% of the variation in the dependent variable (Aggregate Sizes) is explained by the independent variables while the remaining 1.2% is explained by other factors outside the model. The results also show that the F statistics value is 298.95 and the P value is 0.000<0.005. Hence, the model is significant in explaining the relationship between Aggregate size and compressive strength of concrete.

5. Conclusion

Given a constant water to cement ratio (0.5) and mix (1:2:4), a change in coarse aggregate size affected the workability (slump) of concrete. The workability (slump) was directly proportional to the aggregate size. It increased from 10.0 mm, 13.5 mm to 20.0 mm for the 10 mm, 15 mm and 20 mm, respectively. As the slump increased, the concrete became more workable. The mean compressive strength of the concrete aggregates was assessed and found to increase with increasing aggregate sizes. The aggregate sizes 10 mm, 15 mm and 20 mm had mean compressive strengths of 15.32 N/mm^2, 18.21 N/mm^2 and 19.51 N/mm^2, after 7 days, 17.74 N/mm^2, 19.65 N/mm^2 and 21.39 N/mm^2, after 14days 20.53 N/mm^2, 21.86 N/mm^2 and 25.26 N/mm^2 respectively. The regression analysis shows that there exists a strong relationship between the aggregates size and compressive strength of concrete after 7, 14 and 28 days of curing.

It can be concluded that, aggregate with 20mm size most workable fresh concrete and produced the strongest concrete cube.

Sufficient strength of the concrete cube will prevent any structure from failing thereby devoid of retrofitting.

6. Recommendations

The study recommended that:

1. Coarse aggregates with the appropriate size must be used in the production of concrete in accordance with the specified concrete strength and workability.

2. Mix ratio design, batching and mixing of materials must be effectively monitored and supervised by professional builders and engineers to ensure that the right quantity and sizes of materials are employed as this is a critical aspect of quality control.

3. The weight batching method is highly acceptable as against the current trend of volume batching.

4. Mixing of concrete materials should be by machines (batching plants) since most often manual mixing does not produce concrete with high workability.

References

Neville, A. (2004) "Concrete: From Mix Selection to the Finished Structure – Problem en Route" PCI Journal, November/December.

Waziri B. S., Bukar, A. G and Gaji, Y. Z. (2011). Applicability of quarry sand as a fine aggregate. Continental J.Engineering Science. Vol.6, No.2, pp. 1-6

Anonymous, (2012). Functions and requirements of ingredients of cement concrete. http://weebo.hubpages.com/hub/Functions-and-requirements-of-ingredients-of-cement-concrete. Accessed October, 2016

Hollaway, L. C., 2010. A review of the present and future utilisation of FRP composites in the civil infrastructure with reference to their important in-service properties. *Construction and Building Materials*, 24 (12), pp. 2419-2445

Loannides, M. A. and Mills, C. J. (2006). effect of larger sized coarse aggregates on mechanical properties of portland cement concrete pavements and structures: State Job 1(148030). 30-31.

Akanu-Ibiam N., Aniekan E. I. (2021). Experimental Study on the Effect of Different Coarse Aggregate Sizes on the Strength of Concrete. *International Journal of Engineering and Innovative Research* 3(1), 29-38.

Richie I. U., and Effort O. O. (2020). Effect of Coarse Aggregate Sizes on the Compressive Strength of Concrete using Response Surface Methodology *Journal of Science and Technology Research* 2(1) 129-134.

Kumar P., Abraham B. (2020). Experimental Investigation on the Compressive Strength of Concrete with Different Sizes of Coarse Aggregate *International Journal of Advanced Research in Engineering and Technology, 11(9). 464-472*

Olumide M. O., A. Olufunke O., Emeka S. N., & Patrick O. A. (2018). Effects of Coarse Aggregate Size on the Compressive Strength of Concrete. *Civil Engineering Journal* Vol. 4, No. 4

Bruce R., Ndlangamandla S. (2016). The Effect of Aggregate Size on the Compressive Strength of Concrete. *Journal of Agricultural Science and Engineering*. 2(6) 66-69.

ANALYSIS OF LAND USE CHANGE IN IKOT EKPENE LGA, NIGERIA

Ndifreke M. Etim and Jacob Atser
Department of Urban & Regional Planning, University of Uyo
Email: etim_ndifreke@yahoo.com ; jacobatser@uniuyo.edu.ng

Abstract
This study analyzed land use change in Ikot EkpeneLGA with a view to determining the character of land use, trend and rate of change. Data on land uses were obtained through landsat satellite imagery for the three epochs of 1980, 2000 and 2020; and were used in determining character, trend and magnitude of land Use change in the study area. The imageries were processed using ArcGis 9.1 software. The field checks were conducted with a handheld Global Positioning System (GPS) and field note. Observations of land use characteristics and human imprints were made and recorded. A total of 150 checkpoints were used for ground truthing, this was far higher than the ideal number of checkpoints required and were stored as GPS waypoints. The coordinates (together with descriptions) were imported into ArcGis and added to the GIS database as an event theme and were converted into a data layer. This theme of field coordinates was then used as the basis for assessing accuracy of the interpreted imageries. The use of handheld GPS as opposed to the traditional method of pixel selection made the field verification exercise fast, accurate and reliable. The findings characterized the land use of the Ikot Ekpene LGA into four classes of thick forest, cultivated farm land, built up area and water body. The result of image analysis shows that in 1980, thick forest was the dominant land use covering 45.98% of the study area, cultivated farm land took up 30.65% of the area, Built-up area and water body took up 20.35% and 3.02 % respectively. In the year 2000, cultivated farmland became the dominant land use class with an areal coverage of 56.333km^2 (44.19%), built up area was 45.346km^2 (35.57%), thick forest covered an area of 25.755km^2 (20.20%) and water body had an areal extent of 3.046km^2 (2.39%). However in the year 2020,the built up area was the dominant land use class covering 61.529km^2 (48.27%) of the study area, cultivated farmland covered 33.231km^2 (26.06%), thick forest had an areal extent of 30.158km^2 (23.66%) and water body had an areal extent of 2.562km^2 (2.01%). The built up area increased by 35.591km^2 at an annual change of 20.008%. This study indicates that urban development has greatly induced land use change in Ikot Ekpene Local Government Area with a drastic increase in the built-up area while farmland, water bodies and forests experienced significant decrease, and thus, implies urgent need for environmental conservation and protection. Therefore, these findings serve to provide urban managers with vital information on areas to focus in order to control the changing pattern of land use, at least by lowering its change rate. There is the need for updating the master plan of Ikot Ekpene town and preparation of local plans so as to earmark areas with large expanse of forest as conservation areas.

Introduction

Land use change refers to the set of biophysical transformation of land surface and water bodies driven by an interconnected complex of human and natural processes such as building construction and unplanned disaster (flood) which in turn take charge of the inhabitant's lands (Edewede, 2018). Land use involves both the manner in which the biophysical attributes of land are being manipulated and the intent underlying such manipulations. The magnitude of land use change varies with time, the geographical area, the nature of land cover and the anthropogenic activities going on. The land use pattern of a region is an outcome of natural and socio – economic factors and the utilization of natural resources by man in time and space (Etim *et al*. 2023). Urban development often induces land use changes which are seen by deforestation, loss of fauna, global warming and increase in natural disasters. The aforementioned pressures and the concomitant land use modifications are often followed by mismanagement of agricultural and forest lands. Urban development refers to a systemic upgrade in infrastructure, metropolitan facilities, socio-economic activities and an adequate governance structure with the aim of improving the quality of life of the urban residents (Qurix *et al*, 2020). Urban development is the outcome of social, economic and political developments that lead to urban concentration and growth of cities, changes in the land use and transformation from rural to metropolitan pattern of organization and governance. Rapid urban development results in a tremendous growth of population and buildings in cities, as well as an increasing replacement of natural landscapes by impervious surface areas. Urban development have drastically changed the natural environment with the most common change being the replacement of soil and vegetation with urban features such as concrete, asphalt, and buildings. Human dependence on the physical environment for his basic needs has generated actions and inaction in various areas and at various times, often translating into land conversion, alteration and modification, much of which degrade and severely damage the abiotic and

biotic components of the environment. For instance, since humans have controlled fire and domesticated plants and animals, they have cleared forests to obtain higher value from land. Urban development involves land use changes and this has been a universal and important socio-economic phenomenon taking place all around the world. According to Ofem (2016) urban development is one of the most remarkable developments in human settlements in the world. This process, with no sign of slowing down, could be the most powerful and visible anthropogenic force that has brought about fundamental changes in the landscape pattern around the globe. From time immemorial, humans from different parts of the world have been involved in some kinds of movement especially from a point of relative scarcity to a region of perceived abundance in resources in order to enhance their chances of survival and general well being. One of the most remarkable events in human history that best depicts urban development would be the period of the Industrial Revolution in the 1760s, when workers moved towards industrial and manufacturing sites in a bid to secure jobs in factories as conducting agricultural jobs through manual approaches became absolutely frustrating. In 2011, the United Nations reported that about 3.6 billion (52%) of the world's population were urban dwellers and that the level of urbanization is expected to rise to 67% by 2050. In the less developed regions the urban population is expected to rise from 47% in 2011 to 64% by 2050. This implies that urban population in developing countries is on the increase with increasing ubiquitous city expansion encroaching into their hinterlands.

Most recent urban centres grew up as seats of various tiers of Government e.g. Abuja, various state capitals and Local Government Headquarters. These administrative headquarters have the capacity of drawing great population of people from neighbouring villages as they are noted to have opportunities for viable employments and basic infrastructural facilities. Before the arrival of European colonial entrepreneurs at Oron in 1879 and Ibeno, Ukat and Eket in 1881, there was no record of settlements that could be regarded as urban in the area now called Akwa Ibom State (Akpabio and Ofem, 2019). In Akwa Ibom state, urban Development can be attributed to three imperial agencies namely: European colonial administrators, missionaries of Christian faith and European entrepreneurs who came, settled and expanded in their preferred locations. Owing to the removal of the King Jaja of Opobo from power in 1887, and the subsequent subjugation of the area by the British, European entrepreneur migrated in and established trading stations at Oron, Ikpa, Nwaniba, Itu, Eket, Etinan and Ikot Abasi (Egwenga). Also, the establishment of local administrative headquarters at Ikot Abasi, 1903; Ikot Ekpene, 1904; Eket 1905; Uyo, 1905; Itu, 1908; and Abak, 1909 with the provision of infrastructure such as administrative offices, post offices, prisons, schools, courts, police stations and routes served as "pull" factors to the centres. Most of these settlements now serve as the foci of urban development in their respective Local Government Areas (Akpabio and Ofem, 2019).

The Urban development of Ikot Ekpene could be traced to 1914, when it became the headquarters of Ikot Ekpene district after the splitting of the former Enyong district. The new Ikot Ekpene District included Uyo and Abak with headquarters in Ikot Ekpene town. Under the British, the Area became the seat of the experiment in local self governance by the British in 1951(Akpabio and Ofem, 2019). Ikot Ekpene was seriously impacted upon negatively by the Biafran war as the area had strategic importance to both the Biafrans and Nigerians, the area changed hands at least three times during the bitter conflict (Etim, 2015). After the war, the new reorganization and state structure led to policies that did not recognize the historic importance of the area as most of the Annang elites were massacred during the war. However, the area has received an impetuous boost in respect of re-modelling and urban renewal activities.

Nigeria is witnessing serious land use changes due to rapid and unplanned urban development which have brought about several undesirable consequences such as loss of farmlands, increase in pollution levels, and loss of biodiversity, increase in urban heat island among others. Ikot Ekpene has enjoyed an urban status since 1914 when it became a divisional headquarters and has grown rapidly due to its strategic location and its socio-cultural status (Akpabio and Ofem, 2019). Changes in the land use pattern of the study area need to be studied and analyzed systematically in order to isolate the underlying factors and their implications for urban planning. By understanding the spatio-temporal land use changes that have occurred, urban managers will be able to plan and manage future urban development so as to avert negative environmental and socio-economic consequences. Unfortunately, such

information is not readily available for decision makers to make informed decisions especially in Ikot Ekpene Local Government Area. Thus, this study is undertaken to provide answers to the following questions: What is the character of land use in the study area from 1980 to 2020; and what are the trend, rate and drivers of land use change in Ikot Ekpene LGA?

Land Use Characterization

Land Use Characterization involves the classification of portions of land in an area into different land use types based on its predominance, relative significance or its association with other land use types that has wider definitions. Land use are usually characterized to take the stock of land cover and land uses and provide relevant information (data and maps) needed for subsequent planning or re-planning in lieu of development for meeting the present needs of a man without compromising the ability of man to develop in the future. Munthali *et al* (2019) carried out change detection in the land use/land cover of Denza District, Malawi by multi –sets of spatio-temporal landsat imageries for 1991, 2001, and 2015. These images were analyzed and characterized into six classes; water bodies, wetland, agricultural land, forest, built up areas and barren land. The classification was done using a maximum likelihood classification algorithm of ArcGis 10.6.The landuse of Suleja LGA was characterized into three classes; vegetation, Agricultural land and Built Up areas. The softwares used were ArcGis 10.0, ILWIS 9.3, ERDAS Imagine 9.1, IDRISI and Global mapper. In his study in southern Kaduna, Ishaya-Goye (2015) characterized the study area in five land use classes; built- up area, agricultural, vegetated land, water body and bare land. Likewise, Okewu (2016) characterized the land uses in Zaria into five classes; built–up, bare surface, agricultural land, water body and vegetation. The land use of Uyo metropolis was characterized into four categories by Ofem *et al* (2019). These were thick bush, cultivated land, farm land and built up area.

Edewede (2018) assessed changes in land cover and land use in Ebonyi State, the land use characterization was categorized into three classes; built -up areas, swamp rice farm and vegetation. Landsat imageries were sourced from United State Geological Survey (USGS) website; these imageries were analyzed using supervised classification method in the ERDAS IMAGINE 9.2 software. Ukor *et al* (2016) using imageries from google earth PRO, characterized the land use/cover of Ikeja into three classes; settlement, vegetation and shrub land. Classification was done using maximum likelihood algorithm in ArcGIS. Eyo and Ubom (2015) analyzed the land use/cover change trend in Akwa Ibom State, remotely sensed satellite imagery of Landsat TM, ETM and OLI images were acquired and used. Unsupervised and supervised classifications were carried out in ERDAS IMAGINE. The Land use/Land Cover were characterized into five classes; Built Up/bare lands, water, mangrove/primary vegetation and cultivated/mixed vegetation. Ekpenyong (2015) characterized the landuse/land cover of Akwa Ibom State into five categories; built-up/bare soil, farm/fallow land, rivers, secondary forest and swamp forest. Landsat TM and NigerSAT imageries were used a supervised classification was carried out. Fred (2019) characterized the land uses in Abak Local Government Area of Akwa Ibom State into four categories, these were forest, disturbed forest, farmland and built up areas, landsat imageries for 1986, 2001 and 2016 were acquired from united states Geological Survey (USGS) website and were analyzed using Erdas Imagine 9.2 Software. Ekong (2017) characterized the land use/land cover of Ibeno Shoreline into five classes, these were open water, mangrove, forest, bush fallowing and compound farmland. Satellite imageries used were that of Landsat TM 1986, 2008 and Ikono Imagery. Supervised classification was carried out using ArcGIS 9.1 software. Ogar *et al* (2016) studied the changing pattern of forest cover in the stubb's creek forest reserve (SCFR), located in Akwa Ibom State. The land use map was characterized into four classes; dense vegetation(less degraded area), sparse vegetation (high degraded area), bare soil, and water body. Three sets (1993, 2003 and 2013) of satellite imageries were used and an unsupervised classification was carried out using ARCGIS 9.3. From the foregoing, it is safe to say that the characterization of an area's land use is often done according to the interest of the researcher and the physical features of the area. Also worthy of note is that commercial, residential, and industrial land uses are often characterized as one land use type; built up area.

Trend of Land Use Change

Munthali *et al* (2019) analyzed the trend at which the landuse/land cover of Denza District, Central Malawi was changing within 1991 and 2015, it was found out that water bodies reduced from 1380.60 Hectares to 899.55Hectares, a change of -0.13% at an annual rate of -1.78%, wetland areas reduced from 3626.73 hectares to 2680.29 hectares representing a loss of -0.25% at the annual rate of change of -1.26%. The forest experienced a reduction from 9939.15 hectares to 6237.63 hectares representing a change of -0.98% at the annual rate of change of -1.94%. Agricultural land use reduced from 267,977.43 hectares to 260,879 hectares at an annual change rate of -0.11%. Barren land increased from 761.67 to 7999.56 hectares at a rate of 0.22%/ year while built up areas increased from 761.67 hectares to 7999.56 hectares, a change of 1.93% at an annual change rate of 9.8%. Atser *et al* (2014) studied land use changes in Ibiono Ibom, it was found out that the fallowed bush decreased with an annual rate of 34.02 hectares/year, secondary forest increased at the rate of 12.12 hectares/year, forest increased by 12.94 hectares/year, the trend of change in water bodies land use was a decrease of 0.33 hectares/year while compound farm land increased by 0.75 hectares/year. The trend of rural –urban migration in the area was cited as the major cause for forest rejuvenation. Ogar *et al* (2016) found that in 1993, the dense forest accounted for 43.45% of the stubb creek forest in Akwa Ibom state while sparse forest accounted for 55.25%, bare soil was 0.61% and water bodies covered 0.68% of the area. By 2003, the dense area was reduced to 29.04%, the sparse forest increased to 68.77%, the bare soil added to 1.57% and the water body was reduced to 0.65%. By 2013, the dense area further reduced to 19.32%, the degraded land area increased to 77.40%, the bare soil increased to 2.57% and the water bodies increased to 0.75% of the study area. The dense forest decreased by 33.18% with a change rate of 3.31% per annum in 2003. This decreased continued by 33.5% with a change rate of 3.35% per annum in 2013. Between the year 1993 and 2013, there was a total decrease of 55.56% in dense vegetation land cover at the rate of 2.78% per annum. It was observed through a careful analysis that there was a decline in the rate of change of the dense vegetation. This was attributed to increase in awareness on the importance of the forest reserve, shift in preferred source of energy and concentration of infrastructural development. It was recommended that the degraded forest be restored through tree planting and sustainable planning/management of the stubb forest reserve.

Alfred *et al (*2016) monitored the land use changing pattern with focus on the built –up areas in Suleja LGA, Niger State. The study showed that built-up areas increased from 650.60 hectares in 1980 to 3061; 13 hectares in 2015, an increase of 4637.49 hectares (39%). The study made use of Landsat Imagery of Suleja, data were presented in form of histograms, bar charts, figures, imageries and tables.

Uhwache, Sawa and Jaiyeoba (2015) carried out a study on land use dynamics in Zaria between 1973 and 2009. . The findings indicated that Zaria is experiencing rapid expansion leading to a large chunk of the scrubland, farmlands and even part of the flood plains giving way to residential buildings with built-up areas increasing from 44.27 km^2 in 1973 to 130.25 km2 in 2009, while fadama lands decreased from 146.35km^2 in 1973 to 571.29 km^2 in 2009, plantation/forest decreased from 89.24 km^2 in 1973 to 63.36 km^2 in 2009, scrubland decreased from 1,765.72 km^2 in 1973 to 1,350.39km^2 in 2009 and water bodies from 38.16km^2 in 1973 to 4.20km^2 in 2009. Ukor *et al* (2016) found out that within 2002 to 2013, the built areas in Ikeja increased by 319.64 hectares (10.66%) and shrub land increased by 380.97 hectares (193.06%). This led to the decrease in vegetated lands by 50.28% (a loss of 701.22 hectares). Eke (2016) assessed the impact of urban development on landuse types of Akure for the period of 1972 to 2009. In analyzing the urban expansion of the city, 1972 Mss, 1986 Landsat and Landsat enhanced thematic Mapper plus images for 2002 and 2009 satellite images were used. The findings showed a rapid expansion in the built up area of Akure from 1% in 1972 to 2.46% in 1986, then to 3.90% in 2002 with an annual growth rate of 10.63% and 3.66% respectively. Ekpenyong (2015) noted that during the period of 1986-2007, swamp and secondary forest decreased from 42% and 27% in 1986 to 28% and 3% respectively in 2007. This decrease was at the rate of 9163hectares and 8099 hectares per year respectively. This inferred a high rate of deforestation in the area, during the period also, the built up area in Akwa Ibom state also increased by 37859hectares at a rate of 1802 hectares per year.

Ekong (2017) discovered that between the year 1986 and 2008 in Ibeno shoreline, open water increased at a rate of 13.70sq.km per year, while mangrove forest decreased by 167.87sq.km per year, fresh water forest had a decrease of 158.485sq.km per year, fallowed bush decreased at a trend of 50.345sq.km per

year while compound farmland increased at a rate of 351.20sq.km per year. The study recommended monitoring of shoreline periodically and also advocated the enforcement of development control measures. Fred (2019) studied the effects of land use changes on agriculture in Abak LGA, Akwa Ibom State. The results of the research showed that between 1986 and 2016, the forested land cover decreased by 2312.82 hectares at a rate of 77 hectares a year and the disturbed forest decreased by 433.07 hectares at a rate of 14.43 hectares per year. Farmlands decreased by 40,992 hectares at the rate of 1366 hectares per year, while the built up areas increased by 3338.56 hectares at the rate of 111.29 hectares per year. It was noted that uncontrolled land use change was posing a great threat to agricultural practices in the area.

Etuk (2021) using remote sensing and satellite imageries analyzed the land use changing pattern in Nsit Ibom Local Government Area, Akwa Ibom State for 34 years (1986-2020) the result showed that forest class of land use experienced reduction at the rate of 41.46% per year others experience expansion at the rate of 9.80% for bush fallow, 2.51% for farm land and 27.93% for built-up area. Etim *et al* (2023b) assessed land use change in Itu Local Government Area (LGA), Nigeria. The Relative Shannon Entropy (RSE) measure was used to calculate the variation in the area's land use pattern over the previous three decades using Landsat satellite images from 1992 and 2022.The RSE was determined to be 0.6114, confirming that there was a considerable change in the study area's land use pattern between 1992 and 2022. The findings of this study revealed notable trends in land use change, including a decline in water bodies and wetlands, an increased in the built-up areas and cultivated lands, and a reduction in fallowed land.

Drivers of Land Use Change

The rapid pace of urban development in the third world cities has brought about arbitrary changes in the use of land, this has become evident in most cities to the extent that a piece of land or a building can serve diverse purposes. Rapid growth of cities in most African cities is traceable to rural-urban migration. It appears that large number of migrants to cities originates from smaller urban centers, and particularly from rural areas leading to urban expansion. Munthali *et al* (2019) examined the drivers of land use change in Dedza District of Malawi and the drivers were divided into two groups; the proximate and underlying drivers. Respondents were allowed to rate the factors based on a 5 point likert scale. Poverty was found to be the most important underlying driver of land use change with an index of 0.33, population growth was rated second with an index of 0.332, lack of financial resources had an index of 0.089 and lack of law enforcement had an index of 0.086. Demand for timber, weak government policies, poor access to alternative supply of energy and political interference had very small index ranging from 0.043 -0.008. On the other end, charcoal production, timber and construction were the main proximate drivers of land use change in the study area with the weight index of 0.290, 0.217, 0.114 and 0.101 respectively.

Ofem *et al* (2019) examined the drivers of land use change, visualized as urban sprawl in Uyo capital city. Respondents were asked to indicate the factors responsible for land use change in Uyo and the responses were tabulated and analyzed using frequency count and percentages. The study revealed that of the 390 respondents, 43.3% mentioned population growth as the main driver of land use change, 22.0% of the respondents mentioned economic growth as the main driver, 9.0% of the respondents attributed uncoordinated land use change to physical constraints/undevelopable landforms, 13.7% of the respondents mentioned the desire for home ownership while 12.0% of the respondents attributed land use change to lack of co-ordinate and affordable housing. The drivers of land use change in Fagge LGA, Kano state were examined by Bala (2017), the data was generated through the administration of a structured questionnaire, and the results were used together with points coordinate to produce a map showing the drivers of land use change. The factors were presented in a tabular form and analyzed using frequency count and percentages. The findings showed that the drivers of land cover change were specific to a particular location. The drivers were classified into two groups; socio-economic and environmental factors. The socioeconomic were; urbanization rate, population growth, gross domestic products, gross industrial product, household income and gross economic profit. The environmental factors were exploitation of natural resources, soil type and precipitation. The results showed that urbanization rate was the mega driver of land use change in the area based on the 19% views of the total

survey population which was the highest. This was followed by population growth with 16% of the total views of the respondents. This was verified looking at the drastic change that occurred in the built up areas between 2000 and 2016 in the area. Precipitation suggested a factor of change by 11% of the survey population and this was attributed to incessant flooding of the area. Factors like soil (7%), industrial output (7%), market prosperity (8%), Industrial growth (5%) and natural resource exploitation (1%) were considered as significant drivers. Odjugo, Enaruvbe and Isibor (2015) examined the spatio-temporal pattern of urban growth in Benin City, Nigeria for a period of 26 years (1987-2013) using remote sensing data and geographic information systems techniques. The study also examined the factors driving change in urban land use in the city; and these land use changes were observed to be influenced by the siting of public institutions such as schools, hospitals, government offices and industries. While the study demonstrates the importance of using geospatial technology in the acquisition of data for urban planning and management, the results highlight the influence of infrastructure development on urban growth pattern.

Fred (2019) noted that land use change is determined by spatial and temporal interaction between biophysical factors (eg soil, climate, vegetation and topography) and anthropogenic factors (e.g. population size and density, technological levels, economic conditions, the applied land use strategy, and social attitude and values). Alfred *et al* (2016) analyzed the factors of urban growth in Suleja LGA, Niger State. It was found out that increase in population and the proximity of Suleja to FCT were the main drivers of urban growth. It was observed that the increasing population demands for more land for the construction of housing in order to accommodate the rising population growth. The study recommended planning measures to avoid congestion, pollution, overcrowding, building congestion, overstretching of utilities and crime. Digha *et al* (2018) using the administration of a structured questionnaire to 120 respondents investigated the population induced activities that drive land use change in Calabar metropolis. The results were tabulated and analyzed using frequency count and percentages. It was found out that 34.17% of the respondents attributed land use change to industrialization, 35.50% of the respondents mentioned housing development as the main driver of land use change, urban sprawl was named by 17.50% of the respondents, urban agriculture was choose by 10.83% of the respondents while 5% of the respondents were not able to pin point the driver of land use change in Calabar metropolis. The study recommended zoning regulations and the control of air and noise pollution by the government in order to maintain a sustainable environment. Etuk (2021) utilized factor analysis to assess the factors responsible for the changing pattern of land use in Nsit Ibom LGA, and 14 variables of land use change were adopted. The highest loading was named physical development/household factor and it accounted for 45.308% of the total variance, it loaded significantly on technology, academic attainment, household size, infrastructural facilities and availability of market. Factor two loaded significantly on three variables rainfall, environmental problems and fallow land. This factor was named fallow land/environmental factors and accounted for 11.006% of the total variance. Factor three accounted for 9.76% of the total variance, it was named physical condition and it loaded positively on temperature, arts and culture and physical structure.

Study Area

Ikot Ekpene Local Government Area is located within Latitudes 5°10′ to 5° 30′ North of the Equator and Longitudes 7° 30′ to 7° 45′ East of the Greenwich Meridian. It lies on the North western flank of Akwa Ibom State. It is bounded in the north and west by Obot Akara Local Government Area, in the east by Ikono Local Government Area and in the south by Essien Udim Local Government Area. Its position makes it one of the economic gateways to Akwa Ibom State. Ikot Ekpene is the political and cultural capital of Annang ethnic group. Ikot Ekpene Local Government Area covers about 125km^2. It is historic in local government administration in Nigeria, as it became a premier model local government administrative center in 1951. The population figures of Ikot Ekpene Local Government Area base on the 2006 population census was 141,408 persons (NPC, 2006). This figure was projected to 2020 using compound interest formula and annual growth rate of 2.83% to arrive at projected population of 209001 persons. Ikot Ekpene Local Government Area has a land mass of 128km^2. The topography of the area is generally fairly flat. It has an elevation of about 60.96m (2090ft) above sea level. It has a very good run –off of storm water during and after rainfall. Its sand belongs to the undulating sandy plain

classification. The soil of Ikot Ekpene forms part of the consolidated alluvial deposits of the late tertiary age, they are ferralitic in nature; meaning that it has high iron contents but have low minerals. It is stable, brownish, porous, acidic, and highly leached.

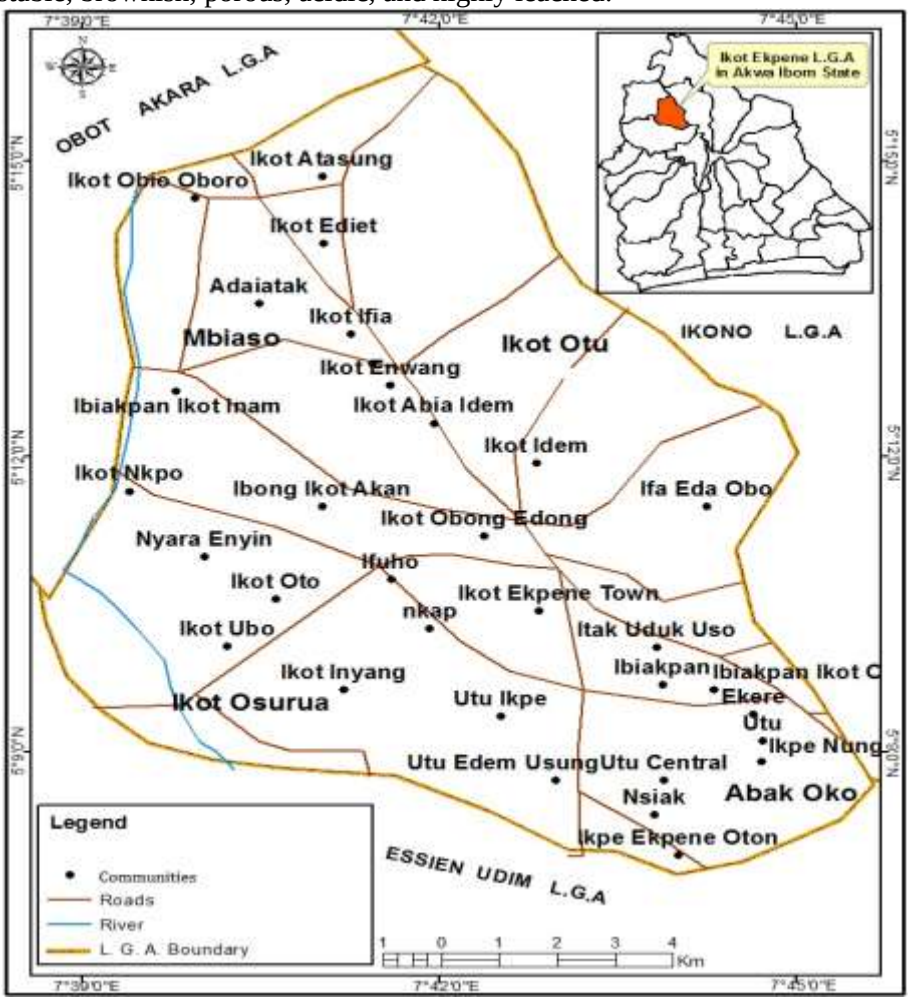


Figure 1: Map of Ikot Ekpene Local Government Area
Source: Cartography Unit, Ministry of Lands, Akwa Ibom State.

The coastal plains have a thickness of about 1.8 meters with clay and gravel particles of which its loose structure is easily eroded. These characteristics of the soil have implications for housing development within the town. The area's soil type can generally be classified as A-2-6 or clayed gravel and sand up to the depths of approximately 5meters. The sub – soil is therefore; generally good for structures and as a base course material for housing development and road construction. Ikot Ekpene Local Government falls within the tropics and thus enjoys a humid tropical climate with mean rainfall of 2311mm, temperature of 28^0C, relative humidity range of 70 to 80 %, and high precipitation of 250mm per annum. The climate is influenced by two main air masses; the equatorial maritime and the tropical continental air masses. The temperature and relative humidity remain fairly constant throughout the year and favours quick plant growth. The area is highly drained by the inland coastal water. The natural resources mostly exploited in the area include palm produce, kernel oil, raffia, gravel, sharp sand, laterite, clay, timber. These unmanaged exploitation has greatly diminish the natural land cover of the area.

This Local government area is habited mainly by the Annang ethnic group. The area was penetrated by the British in 1901 when the famous Aro expedition passed through it. In 1903, the territory was explored by another military expedition, from that year; the people in that locale were brought under colonial masters' control using military coercion. Between 1904 and 1910, Ikot Ekpene became part of the Enyong district. In 1914 Enyong District was broken up into two; Enyong and Ikot Ekpene

Districts. The new Ikot Ekpene District included Uyo and Abak with headquarters in Ikot Ekpene town. Under the British, the Town became the seat of the experiment in local self governance by the British in 1951. It was also the birth place for the famous Ibibio Welfare Union. Ikot Ekpene was seriously impacted upon by the Biafran war as the area had strategic importance to both the Biafrans and Nigerians. After the war, the new re-organization and state structure led to policies that did not recognize the historic importance of the area as most of the Annang elites were massacred during the war (Akpabio, 2010).Despite the advent of western Civilization, there are some cultural institutions that are still in place in the area, these are Ekpo, Ekpe, Idiong, Attat, Utu- Ekpe and Abree. Most of these institutions are used to maintain law and order and to enforce obedience to traditional authorities. Their culture is reflected and displayed through dances, arts and crafts. The people of this area are highly religious. Their belief in a supernatural being dates back to time immemorial. Most of these cultural societies have their sacred grooves, where deforestation of such a place is seen as a taboo. Ikot Ekpene Local Government Area is located in an oil palm belt. Consequently, the people have palm oil and kernel extraction as their major occupation.

Methodology

Data required for this study and their units of measurement are basically those on land uses, drivers of land use change and population growth. This is shown in Table 1.These data were obtained through land sat satellite imagery for the three epoch; 1980, 2000 and 2020. It was acquired from United States Geological Survey website. These data were used in determining status and magnitude of each land use class. Data extracted from the landsat imagery were used in analyzing the trend of land Use change in the study area. The imageries were processed using ArcGis9.1 software.

Table 1: Variables of the Study

S/n	Indices	Definition	Unit of measurement
1.	Forest	This refers to natural vegetation covers that are not altered by human activities. It is made up of a mosaic of grass plains, palm swamps and forest on waterlogged and seasonally flooded soils. Riparian vegetation type also form part of this broad group	Square Kilometer (Km^2)
2.	Farmlands	This is the portion of land used for all forms of cultivation. It is characterized by annual farming with mixed and sequential cropping or mono -cropping	Square Kilometer (Km^2)
3.	Built -Up	This refers to Area of land that has been taken up by buildings, structures and roads.	Square Kilometer (Km^2)
4.	Water Bodies	This refers to the portion of land that is constantly covered by water, this include rivers and streams.	Square Kilometer (Km^2)

Source: Author's Classification (2021).

Based on the priori knowledge of the study area and a brief reconnaissance survey of the study area, a classification scheme was developed for the study area. The land use type was classified in to four classes namely; built up areas, forested areas, cultivated areas and water bodies using supervised classification module in ARCGIS 10.1. Validating accuracy of classification is vital towards placing a premium on generated data (Abubakar, 2015). Validating accuracy of land use classes interpreted from remote sensing imageries requires a validated superior resolution dataset of the same area. In a place such as the study area where such superior data is not available, fieldwork is the best alternative. Reconnaissance field work was carried out which provided an opportunity to establish contacts and familiarization with the communities and indigenous population. The field checks were conducted with a handheld Global Positioning System (GPS) and field note. Observations of land use characteristics and human imprints were made and recorded. According to Abubakar (2015), the ideal number of check points required to be tested on the land use classification map is determined from the binomial probability given in equation;

$N = 4(p)\ (q\sim)/e^2$ - - - - - - - -Equation 1

Where: N = is the number of points required, p = is the expected percent accuracy, q~ = the difference between 100 and p (in percentage), e = is the maximum allowable error or an expected 90% accuracy and allowable error of 5%, and q~ is 10% and the minimum number of points required is 144. A total of 150 checkpoints were used for ground truthing, this was far higher than the ideal number of

checkpoints required. The checkpoints were stored as GPS waypoints. The coordinates (together with descriptions) were imported into Arc GIS and added to the GIS database as an event theme which will then be converted into a data layer. This theme of field coordinates was then used as the basis for assessing accuracy of the interpreted imageries as described by Abubakar (2015). The use of handheld GPS as opposed to the traditional method of pixel selection made the field verification exercise fast, accurate and reliable.

Land use characterization of the study area.

The land use of the Ikot Ekpene LGA was characterized into four classes; thick forest, cultivated farm land, built up area and water body. The result of image analysis shows that in 1980, thick forest was the dominant land use covering 45.98% of the study area, cultivated farm land took up 30.65% of the area, Built-up area and water body took up 20.35% and 3.02 % respectively. In the year 2000, cultivated farmland became the dominant land use class with an areal coverage of 56.333km^2 (44.19%), built up area was 45.346km^2 (35.57%), thick forest covered an area of 25.755km^2 (20.20%) and water body had an areal extent of 3.046km^2 (2.39%). However in the year 2020,the built up area was the dominant land use class covering 61.529km^2 (48.27%) of the study area, cultivated farmland covered 33.231km^2 (26.06%), thick forest had an areal extent of 30.158km^2 (23.66%) and water body had an areal extent of 2.562km^2 (2.01%). The land use characterizations of Ikot Ekpene LGA for the year 1980, 2000 and 2020 are presented in Table 2.

Table 2: Land Use Characterization of the Study Area as at 1980, 2000 and 2020

Land Use Classes	1980 (Km^2)	%	2000 (Km^2)	%	2020 (Km^2)	%
Thick Forest	58.611	45.98	22.755	17.86	30.158	23.65
Farmland	39.04	30.66	56.333	44.19	33.231	26.07
Built-up Area	25.938	20.34	45.346	35.57	61.529	48.27
Water body	3.847	3.01	3.046	2.39	2.562	2.01
Total	127.480	100.00	127.480	100.00	127.480	100.00

Source: Extracted from LandSat Imageries 1980, 2000 and 2020 of Ikot Ekpene LGA.

Figure 2: Land use/Land Cover Classified Images of the Study Area in 1980

Trend of Land Use Change in Ikot Ekpene Local Government

The second objective was to examine the trend of land use change in the study area. The land use/cover mapping extracted from the extents of land use change in Ikot Ekpene LGA as derived from the analysis of the 1980, 2000 and 2020 satellite imageries is presented in tables 3-5.

Table 3: Trend of Land Use Change in the Study Area, 1980 -2000

Land Uses Classes	1980 (Km^2)	2000 (km^2)	Magnitude of Change (Km^2)	% of Change	% Annual Change	Nature of Change
Thick Forest	58.611	22.755	-32.856	46.73	9.346	Reduction
Farmland	39.084	56.333	17.249	24.53	4.906	Expansion
Built-up Area	25.938	45.346	19.408	27.60	5.520	Expansion
Water body	3.847	3.046	-0.801	1.14	0.228	Reduction
Total	127.480	127.480	70.314	100.00	20.00	

Source: Extracted from LandSat Imageries 1980 and 2000 of Ikot Ekpene LGA.

Figure 3: Land use/Land Cover Classified Images of the Study Area in 2000

Figure 4: Land use/Land Cover Classified Images of the Study Area in 2020

Table 4: Trend of Land Use Change in the Study Area, 2000 -2020

Land Use Classes	2000 (Km^2)	2020 (Km^2)	Magnitude,of Change (Km^2)	% Change	% Annual Change	Nature of Change
Thick Forest	22.755	30.158	4.403	9.33	1.87	Expansion
Farmland	56.333	33.231	-23.099	48.97	9.79	Reduction
Built-up Area	45.346	61.529	19.183	40.67	8.13	Expansion
Water body	3.046	2.562	-0.484	1.03	0.21	Reduction
Total	127.480	127.480	47.169	100.00	20.00	

Source: Extracted from LandSat Imageries 1980, and 2020 of Ikot Ekpene LGA.

Table 5: Trend of Land Use Change in the Study Area, 1980 -2020

Land Uses Classes	1980 (Km^2)	2020 (Km^2)	Magnitude of Change (Km^2)	% Change	% Annual Change	Nature of Change
Thick Forest	58.611	30.158	-28.453	39.99	15.996	Reduction
Farmland	39.084	33.231	-5.853	8.18	3.272	Reduction
Built-up Area	25.938	61.529	35.591	50.02	20.008	Expansion
Water body	3.847	2.562	-1.285	1.81	0.724	Reduction
Total	127.480	127.480	71.152	100.00	40.000	

Source: Extracted from LandSat Imageries 1980, 2000 and 2020 of Ikot Ekpene LGA.

The thick forest category is made up of the relics of the high forest and the fragmented secondary forests scattered all over the study area. In 1980, the base year, forest covered a total land area of 58.611$km^{2,}$ while that for 2020 was 30.158Km^2. This indicates a declining trend within the 40years under study. This however represents about 39.99% of the total change in land use in the area. From Table 3, within the period of study, thick forest witnessed a reduction at an annual change percent of 15.996%. In this study, findings indicate that cultivated farmlands have experienced decrease in its size over the past four decades. In 1980 cultivated farmland covered 39.084Km^2, while that in 2020 was found to be 33.231Km^2. In this regard, the magnitude of change was 5.853km^2. This represents about 8.18% of the total change in the entire study area. This reduction is understandable since built-up areas have actually expanded into the farm lands. The built-up area land use pattern has shown an expansion of 35.591km^2 over the study period of 40 years. This implies that the built-up areas have been expanding at an annual percentage of 20.008% per year. Built-up land use represents 35.591% of the total changes in the area. This is however not in doubt as developments are evident around Ikot Ekpene Town, Ikot Asura and adjoining areas. Areas that were previously compound farmland, farmland, bush fallow and even forests have been converted to this land use; this is made possible by road construction, markets establishments, government offices, etc. The water body class of land use has been on a declining trend over the past four (4) decades, with an area of 3.847km^2 in 1980, the size of this land use class reduced to 2.562km^2 in 2020. The percentage annual change of this land use is 0.724, the magnitude of change is 1.285km^2 and it contributes 1.81 % to the total change percentage.

The land use of Ikot Ekpene Local Government Area was characterized into four classes; thick forest, cultivated farm land, built-up area and water bodies. As at 1980 the thick forest was the dominant land use and these agrees with many scholarly works which show that before urban development occurs the thick forest was the most dominant land use. With man's exploitation of the natural resources and the need for land to accommodate under uses needed for the day to day complex activities of man, the forest have been degraded into farm lands and built up areas. The cultivated farmland benefitted from the decrease in forested lands between 1980 and 2000 as more people engaged in farming activities, however between 2000 and 2020 the areal extent of cultivated farmland decreased by 23.099km^2 at an annual change rate 9.79%, this can be attributed to the abandonment of agriculture for other lucrative jobs, too much dependence on politics and is also caused by the emigration of young ones to bigger towns thereby lowering the man power for agricultural activities, this agrees with the views of Atser *et al* (2013) who observed a similar trend in Ibiono Ibom LGA. The reduction in water bodies in the study area can be attributed to climate change, building and farming on wetland regions. The built up area in the study area have been found to have increased by 35.591km^2 at an annual change percent of 20.008%, this means that housing development, road construction and sitting of facilities like schools,

hospitals and markets have been on an increase. The expansion of this land use is at the expense of the other ones especially cultivated farmlands and thick forest. However, this annual rate increase of 20.008% is less than that reported by Etuk (2021) in Nsit Ibom LGA which was 27.93%. Previous researchers such as Fred (2019) and Etuk (2021) asserted that increased urban development leads to loss of agricultural lands, the findings of this research affirm that urban expansion takes over agricultural lands and natural vegetation. Water bodies are shrinking up in the study area; this can be explained by climate change and encroachment of wetlands by other uses.

Conclusion and Recommendations

Land use change is a complex process that arises from modifications in land cover to land conversion process and thus serves as one of the main drivers of environmental change. This study indicates that urban development has greatly induced land use change in Ikot Ekpene Local Government Area with a drastic increase in the built-up area while farmland, water bodies and forests experienced significant decrease, and thus, implies urgent need for environmental conservation and protection. Land use management crisis will continue to exist unless there is deliberate control of urban development. Therefore, these findings serve to provide urban managers with vital information on areas to focus in order to control the changing pattern of land use, at least by lowering its change rate. There is the need for updating the master plan of Ikot Ekpene town and preparation of local plans so as to earmark areas with large expanse of forest as conservation areas.

References

Abubakar, A. (2015). *Effects of Urbanization on Landuse/Landcover Changes in Birnin Kebbi, Kebbi State, Nigeria.* M.Sc (GIS and Remote Sensing). Ahmadu Bello, University, Zaria. Nigeria.

Abubakar, K. (2015). *Land Use - Land Cover Changes and their Implications in Nigeria using Geospatial Technique* . M.Sc Dissertation (GIS and Remote Sensing). Ahmadu Bello, University, Zaria. Nigeria.

Akanmu, A., Daramola, O.,Ogunsesan, A., and J. Asejare (2019). Guide to Professional Planning Practice Examinanation in Nigeria. Ibadan: Penhouse Publicatios(Nig.)

Akpabio, M. and Ofem, B. (2019). Urbanization and Urban Development in Nigeria: A Perspective of Akwa Ibom State. *Journal of Agriculture, Environmental Resource and Management* 4(2) 369-384.

Akpabio, P. (2010). *Analysis of Housing conditions in Ikot Ekpene Urban*. Masters Dissertation, Dept. of Urban and Regional Planning, University of Uyo.

Alfred, B., Gillian, M., and A. Justina (2016). Urban Growth and Land Use Cover Change in Nigeria using GIS and Remote Sensing Applications. Case Study of Suleja LGA, Niger State. *International Journal of Engineering Research (IJERT) Vol. 5(8) 124 - 138.*

Atairet, A. and K. Mboho (2019). Sustainable Development: Issues and Challenges. In Ibok, E., Daniel, E., and Atakpa, O. (eds), The Politics of Global Environmental policies. Calabar: University of Calabar Press.

Atser, J. (2015). "Introduction" in Ikurekong E. (Eds), Introduction to Landuse Planning Practice. Uyo: Art Biz Global Effects.

Atser, J., Ekong, F., Ituen, U., and E. James (2014). Indigenous Land Management Practices and Land Cover Change in Akwa Ibom, Nigeria. Journal of Environmental Protection 5(1) 1541-1552

Bala, I. (2017). Geospatial Implications of Land Use Change in Fagge Local Government Area, Kano State. *A GIS Doctoral Thesis, Obafemi Awolowo University, Ile Ife-Osun State.*

Bello, H., Ojo, O. , and A. Gbadegesin (2018). Land use/Land Cover Change Analysis using Markov-Based Model for Eleyele Reservoir. *Journal of Applied Science, Environment and Management. Vol. 22(12) 1917-1924.*

Daniel, E. and N. Nwaowo (2018). Landscape Planning and Sustainable Ecological Management of Nigerian Universities: Akwa Ibom State University Example. *International Journal of Geography and Regional Planning Research*. 4(1) 1-9.

Daniel, E and R. Udo (2019). Human-Environment Interactions. . In Ibok, E., Daniel, E., and Atakpa, O. (eds), The Politics of Global Environmental policies. Calabar: University of Calabar Press.

Digha, O., Imaitor, E., Ariwadum, M., and C. Osuji (2018). Influence of Population Growth on Land use Change in Calabar Metropolis, Nigeria. *Journal of Research in Environmental and Earth Science 4(1) 01 -14.*

Edewede, D. (2018). Assessment of Changes in Landcover and Landuse in Ebonyi State, Using Remote Sensing Technique. *Journal of Environment and Earth Science Vol. 8 (9).*

Eke, E. (2016). Analysis of the Urban Expansion of Akure, Ondo State, Nigeria. *International Letters of Social and Humanistic Sciences.*75 (1) 41-55

Ekong, F. (2017). GIS Based Analysis of Shoreline Change in Ibeno, Akwa Ibom State, Nigeria. *Journal of Environmental Protection 8, 637-649.*

Ekpenyong, R. (2015). An Assessment of the Nature of Urban Growth and Development in Akwa Ibom State, Nigeria. *International Journal of Geomatics and Geosciences.* 6(1) 68-80

Ekpenyong, R. (2015).Analysis of the Locations of Land Cover Change in Akwa Ibom State, Nigeria. *Journal of Environment and Earth Vol.5, No.8, 2015.*

Esenowo, I. and A. Akpan (2019). Climate Change and Sustainable Development in Africa. In Ibok, E., Daniel, E., and Atakpa, O. (eds), The Politics of Global Environmental policies. Calabar: University of Calabar Press.

Etim, N. (2015). *An Assessment of Residential Area Preference Among Residents of Ikot Ekpene – Urban*. BURP Project. University of Uyo, Nigeria.

Etim, N., Mfon, I., Etuk, E. and Udoh, V. (2023). An Assessment of Landuse Change in Nsit Ibom Local Government Area, Akwa Ibom State, Nigeria. *Journal of Environmental Design 18(1) 98-112.*

Etim, N., Attah, A. and Okon, M. (2023b)**.** An Assessment of Land Use Change in Itu LGA, Nigeria: The Application of Relative Shannon Entropy. *International Journal of Research Publication and Reviews 4(7) 2911-2919.*

Etuk, E. (2021) *Effect of Changing Land Use Patterns on Livelihoods in Nsit Ibom LGA*. M.Urp dissertation University of Uyo, Nigeria.

Eyoh, A. and O. Ubom (2016). Spatio-Temporal Analysis of Land use/Cover Change Trend of Akwa Ibom State, Nigeria 1986-2016 using Remote Sensing and GIS. *International Journal of Science and Research; 5(10).*

Fred, J. (2019). *Effects of Land use Changes on Agriculture in Abak Local Government Area, Akwa Ibom State (1986 -2016).* M.Sc (Environmental Management). University of Uyo, Nigeria.

Ishaya - Goje, M. (2015). *Analysis of Land Use and Land Cover Change in Southern Part of Kaduna Metropolis, Kaduna State, Nigeria*. MSc (GIS) Dissertation. Ahmadu Bello University, Zaria. Nigeria.

Israel, U. (2018). Urbanization and Conflict: A Study of Uyo, 1990 -2015. African Journal of History and Archaelogy 3(1) 35-49.

Jianchu, X., Jeff, F. and M. David (2015). Land Use Transition, Livelihoods and Environmental Science in Montane Mainland SouthEast Asia. *Mountain Research and Development, 26(3):278-284*

Monzon, A. (2015). Smart Cities Concept and Challenges: Bases for the Assessment of Smart City Projects. In M.Helfert., K.Krempels., C.Klein., B. Donnellan. and O. Gusikhin. (Eds.) *Smart Cities, Green Technologies, and Intelligent Transport Systems.* 4th International Conference, SMARTGREENS, 2015 and 1st International Conference on Vehicle Technology and Intelligent Transport Systems (VEHITS), Lisbon, Portugal, May 20-22.

Munthali, M., Davis, N., Adeola, A., Botai, J., and J. Kamwi (2019). Local Perception of Drivers of Land Use and Land Cover Change Dynamics Across Dedza District, Central Malawi Region. *Journal of Sustainabilty Vol. 11(3) 1-25.*

Odjugo, P.A., Enaruvbe, G.O, and Isibor, H.O. (2015) Geospatial Approach to Spatio Temporal Pattern of Urban Growth in Benin City, Nigeria. *African Journal of Environmental Science and Technology*. Vol. 9(3) 166-175.

Ofem, B., Atser, J. and Obot, B., (2019) Effects of Urban Sprawl on Peri –Urban Farming Communities in Uyo Capital City, Akwa Ibom State. *A Journal of Faculty of Environmental Studies, University of Uyo, Uyo, Vol. 14(1).*

Ofem, I. (2016). Application of Multivariate Analyses in Classifying Urbanizing Settlements in Akwa Ibom State, Nigeria. In Atser, J. (ED), Modern Quantitative Research Design and Applications in Environmental Studies. Enugu: Immaculate Publications Limited.

Ogar, D., Asuk, S and I. Umanah (2016). Forest Cover Change in Stubb's Creek Forest Reserve, Akwa Ibom State, Nigeria. *Journal of Applied Tropical Agriculture, Vol 21(1).*

Okewu, A. (2016). *Urban-Induced Landuse / Landcover Changes in Zaria Kaduna State, Nigeria*. M.sc (GIS) . Ahmadu Bello University, Zaria, Nigeria.

Okosun, A., Nwachukwu, M., Obasi, J., Jiburum, U., and D. Okeke (2019). Analysis of Factors that influence Land Use Dynamics in Nigeria. *Journal of Architectural Drawing,* 4(2) 1-14.

Opatoyinbo, O., Adepetu, A., and M. Abdullahi (2015). Population Growth and Urban land use Change along River Kaduna Floodplain. FIG working week 2015, Sofia, Bulgaria.

Qurix, B., Edomwonyi - Otu, L. and D. Jise (2020). An Assessment of Urban Development and Control Mechanisms in selected Nigerian Cities. Retrieved from www. Preprints.org on 12th December, 2020.

The National Academy of Science (2019). Proceedings of the National Academy of Sciences of the United States of America Vol. 110: 7978-7985.

Udoudo, F. (2016). Real Estate and Infrastructure Economics in Urban Nigeria. Uyo: MEF (NIGERIA) LTD.

Uhwache, G.M., Sawa, B.A., and Jaiyeoba, I.A. (2015), Multi-Temporal Remote Sensing of Landuse Dynamics in Zaria, Nigeria. *Journal of Environmental and Earth Science, 5(9); 121-138.*

Ukor, C., Ogbole, J and A. Alaga (2016). Analysis of Land Use Cover Change in Ikeja, Lagos State Using Remote Sensing and GIS Techniques. *International Journal of Science and Technology. Vol 5(10) 462 -472.*

COASTAL TOURISM AND CONSERVATION OF RESOURCES IN IBENO, AKWA IBOM STATE, NIGERIA: AN ECOLOGICAL IMPACT

Beulah I. Ofem and Nkebet Umah
Department of Urban and Regional Planning, University of Uyo, Uyo, Akwa Ibom State
Email: beulahofem uniuyo.edu.ng
Phone: 08023180512

Abstract
The study examined the impact of tourism on the conservation of resources/ecology of Ibeno LGA. A survey design was adopted for data gathering. Inferential and descriptive statistics were used in analysing quantitative and qualitative data. Respondents made up of residents, and tourists were purposively sampled from 25 villages for questionnaire administration. Information was obtained directly from the study area through observation and questionnaire. Units for the measurement of independent and dependent variables for the study were the five point Likert summative rating scale of Strongly Agree (5), Agree (4), Neutral (3), Disagree (2) and Strongly Disagree (1). A cumulative link between tourism and the conservation of coastal resources in Ibeno LGA was revealed in the study and that if tourism industry, tourism infrastructure, and clinic/accessibility factors are developed without integration of management, the natural environment will be eroded. Therefore, the study revealed that the level of conservation of coastal resources in the study area as is low. Based on the findings, it is recommended that Sustainable/ecotourism should be adopted for tourism development in the study area. This can be done by planned and controlled tourism development as well as integrated coastal management.
Keywords: *Coastal Tourism, Conservation, Resources, Ecosystem, Environment, Degradation*

1.0 **Introduction**

Coasts possess some unique features which make them attractive for tourism activities. According to Alipour *et al*. (2007) coastal areas provide the main tourism resources, and one of the main reasons why coasts are so important for tourism is that visitors are strongly attracted to them (the weather, climate, vegetation, quality airspace, sunshine, beautiful scenery, rocks, falls, captivating beaches, fine landscapes, birds, fish, marine mammals and other wildlife) and by associated rich cultural interests (coastal towns, villages, historic relics, friendly people, ports, fishing fleets, markets and other aspects of maritime life).

However, this special environment (coast) is sensitive and fragile (Tuhin, 2012), and in dare need of conservation. According to Sorice (2007), conservation is the care and protection of earth's natural resources so that they can persist for future generations. It involves maintaining diversity of species, genes, and ecosystem, as well as functions of the environment, such as nutrient cycling. Conservation seeks the sustainable use of these resources by humans. Goodhead and Johnson (1996); and Ofem and Inyang (2019) acknowledged that many coasts contain valuable habitats and have a very rich biodiversity. Land, water and other natural resources are often scarce on the coast, partly as a result of the focus and pressure of urban development and activities in these areas. The communities surrounding these coastal areas are also greatly influenced by the tourism industry.

Tourism encompasses the activities of persons travelling and staying in places outside their usual environment temporarily for not more than one consecutive year for leisure, business, and other purposes (WTO, 2002; UNWTO, 2016). According to Tuhin (2012) about 30% of the world's tourism is on the coast or within the coastal zone and in addition the economy of that area depends on the coastal tourism besides their other professions like fishing, agriculture and mining. Globally, coastal areas are the most visited by tourists and tourism presents the most important economic activity (Burke, 2001). There are nearly 200,000,000 jobs created every year which allows for coastal tourism to catapult locals into better financial situations, sometimes even out of poverty (Kline, 2001). The income generated from coastal tourism contributes to local Gross Domestic Product (GDP) and further economic stability. People come to coastal areas to find havens of peace and leisure, enunciating how much we care about these spaces for our mental health and relaxation. Balancing pleasure with education and advocacy will help boost the overall awareness about how important coastal areas are to our communities and the tourists that choose these kinds of destination for an escape (Gill *et al.*, 2003).

In Nigeria, there are possible benefits of coastal tourism to the economy, society and the environment as well as issues and challenges. The positive benefits are revenue generation, local job creation and

prosperity. The challenges and issues relate to physical destruction and loss of amenity, loss of habitat and biodiversity, pollution and resource consumption. In Akwa Ibom State (AKS), the availability of tourism resources and potentials have made the development of the tourism industry undergo a gradual evolution, with each phase reflecting its growing importance in the economy (Udoh, 2019). Ibeno Local Government Area (LGA) in AKS is not left out on this evolution. The Ibeno coastal area being a transitional area between the land and sea is characterized by a very high biodiversity, unique resources, and some of the richest and most fragile ecosystems. This underscores the need to examine the impact of tourism on the resources/ecology of Ibeno LGA.

2.0 **Research Problem**

Ibeno LGA possesses some unique coastal features. These features are resources which are of great benefits to the locals and also as tourism potentials attracting tourists to the area. An example is the Ibeno beach which is the focal point for coastal recreation and tourism; and a source of revenue for the locals as people are willing to travel and spend large sums of money to lie, sit, or walk on the beach. While good beaches attract tourists and liberal spending, degraded beaches discourage tourism. Rapid and uncontrolled tourism development in the study area has exposed its fragile ecosystems to an ever-increasing risk of environmental degradation. Overcrowding, poor sewage disposal, boat-generated waste, beach erosion, overfishing, and destruction of wildlife habitats have been reported as some of the negative consequences of excessive tourism development affecting natural resources in the Ibeno coastal areas. The deteriorating situation has caused loss of livelihoods and income which has led to socio-political instability (UNEP, 1995; Buckley, 2012). Inappropriate or unplanned development as observed in the area may lead to habitat degradation and biodiversity loss, and misuse of natural resources such as decline in freshwater quality, forests and wetland (Udoh, 2019). The communities in Ibeno LGA are caught in the dilemma of tourism of interest and the income it generates while deploring the negative social and environmental impacts.

Therefore, if environmental damages get out of hand, this will lessen the attractiveness of the destination for tourists and eventually the destination's tourism industry might become damaged as well through its own activities. Also, Ibeno LGA and her people may not be able to pass on these coastal resources to future generations.

3.0 **Study Area**

The study area is Ibeno LGA in Akwa Ibom State, located in the Niger Delta region of Nigeria. It is a stretch of coastal area along the Bight of Bonny on the Atlantic Ocean. It has a shoreline approximately 56.7 km in length and spans from a point at Atabrikang village on latitudes 4˚31´ and 4˚ 34´N; and longitudes 7˚49´ and 8˚17´E to Okposo village. It is bounded in the south by the Atlantic Ocean and shares border with Eket, Esit Eket, Onna, Mbo and Eastern Obolo LGAs. The land area of Ibeno LGA is 247,575km^2. Figure 1 shows the map of Ibeno LGA in Akwa Ibom State. The projected population of Ibeno LGA based on the 1991 National Population Census figure of 41,543 at 2.83% growth rate was 93,378 in 2022.

Figure 1: Ibeno Local Government Area on the map of Akwa Ibom State
Source: Google Map (2022)

4.0 **Review of Related Literature**

The coastal zone is essential for marine life and supports a large part of the world's living marine resources. Its wetlands, lagoons, sea grass beds, coral reefs and shallow bays are nursery or feeding areas for most coastal and many oceanic species (Kline, 2001; Hall and Page, 2006). This zone has the highest biological diversity of any part of the sea (Jennings, 2004; Yunis, 2006). While the whole ecosystem is the focus of management, each of its structural parts and essential processes must be conserved - with emphasis placed on critical areas. For example, the mangrove forests, tide flats, beaches, sea grass or kelp beds, and coral reefs need special attention (Swaney *et al.*, 2012). This coastal environment is resourceful and attractive for tourism development.

All tourism forms and activities rely on the use of environmental resources. Even if it is considered as a "soft" industry, tourism has a major environmental impact on many coastal areas, which are particularly vulnerable to pressures associated with its growth. The relationship existing between tourism and environment is best qualified as that of mutual dependence; not only that tourism is highly dependent on environmental quality but environmental quality is also highly vulnerable to tourism development. The impacts of tourism on coastal areas can be both positive and negative (Coccossis and Mexa, 2004). Coastal communities certainly benefit from tourism through the creation of employment opportunities, the raising of revenue, the development of infrastructure, improvements in health and safety conditions and enhancements of aesthetic standards. Large tourism developments have dramatically altered not only the visual aspect of many coasts around the world but also the natural

dynamics of coastal ecosystems. Land-grab and demand for resources are at the root of severe erosion phenomena, loss of valuable habitats (such as sand dunes, coral reefs, wetlands and mangrove forests), the irreversible destruction of pristine areas, and the loss of rare animal and vegetal species (Coccossis and Mexa, 2004).

Marine pollution may also result from the discharges from tourist yachts, excursion boats, car ferries and, particularly, cruise ships. These "floating towns", with a capacity of up to 4,000 passengers, are considered "a major source of marine pollution through the dumping of rubbish and untreated sewage at sea, and the release of other shipping-related pollutants" (WWF, 2007). Besides ecological damages, tourism may impact negatively on the local society. The impact of tourism on traditional lifestyle and local customs, the erosion of traditional socio-cultural values and the loss of identity of the local population, and the devaluation of property values due to overbuilding are some of these negative impacts.

Moghimehfar and Halpenny (2016) admitted that all ecological impacts on the host destinations are practically as a result of tourists' activities. A meta-analytical study by Evans *et al.* (2011) on fisheries co-management highlighted the necessity of evaluating impacts on the environment, considering it as an important research and practice requirement in development and natural resource management. In evaluating environmental impacts, it is therefore necessary to distinguish between human impacts and natural agents of disturbance (Rouphael *et al.*, 2010).

Individual perspective of the effects of tourism on the environment may be relative in terms of position in the resource chain. For example, a Marketer may view it as beneficial, a nature watcher may view it as negative, and a victim of imported ailment may view it in an individual dimension, different from the other two perspectives. What makes these effects positive or negative is dependent on; the scale of tourism; size of the resource being harnessed; and relative use of the resource (Hall, 2001; Buckley, 2011). More so, studies have identified several physical environmental global effect that have been associated with tourism, such as, environmental degradation, coastal debris, pollution, resource depletion and environmental health (Davenport and Davenport, 2006; Buckley, 2011; Silva and Ghilardi-Lopez, 2012).

Coastal tourism is considered to have several negative effects on the coastal destinations, especially with pressure on the limited resources available in such destinations (Tuhin, 2012). Hence, in their findings on sustainability measure, Altinay and Bicak (2005) suggested water quality, solid waste disposal, road traffic, natural vegetation and wild life have significant effect variables in tourism area. Land consumption is considered of most significant effect in the Balearic islands (WTO 2004); pollution, loss of natural landscape , flora and fauna destruction and degradation of landscape and site have been highlighted in the study on the Greek Island of Mykonos (Coccossis and Njikamp, 1996). Erosion, though the least noticed by visitors was considered as one of the graver environmental problems from tourism in Rhodes Island (Hughes, 1994).

These effects have led to clamour for conservation, ecotourism, sustainable development and the creation of management initiatives (Lawrence, 2000; Stern 2000) such as Integrated Coastal Zone Management and the United Nations programme of Small Islands Developing States (SIDS). The oceans and seas may be vast and viewed as endless, yet it is evident that available resources from them are scanty, so also are the coastlines and coastal resources (Earle, 1995).

The coastal system has continued to change globally in response to both natural and human factors. A phenomenon of concern in the last quaternary attributed to climate change is rise in sea level, where this has greatly influenced changes to several coasts globally posing several dimensions of threat to sustenance (Nicholls *et al.*, 2007; Moss, 2012; Mauz *et al.*, 2012; Woodroffe and Murray-Wallace, 2012). The bid to catch up with globalization through economic development has continued to result in changes to the coast either on large scale or gradually in some destinations (Creel 2003; Switzer *et al.*, 2012).

One such human activity that contributes to the continued use and modification of the coastal system are developments that characterize tourism within the coastal area, where this has generated influences in varying forms. Coastal tourism and development is identified as one of the major causes of coastal degradation (WWF, 2013) especially in priority places such as Small Island States in the Mediterranean basin, being home to irreplaceable and threatened biodiversity (Swaney *et al.*, 2012; Switzer *et al.*, 2012).

With the influx of human visitation from many different geographical regions, non-native species are observed at a higher propagation rate in these areas. Typical recreation activities such as hiking, biking, and off-road driving can act as habitat disturbances which may increase the spread of aggressive invasive species, harming the natural ecosystem. This can have dire consequences on local flora and fauna as invasion trend is successful in colonizing disturbed areas where the local biotic communities have been affected and potentially harmed (Kertesz, 2009). Until various approaches to integrated tourism are adopted the world will continue to lose valuable quality ecosystems.

5.0 **Research Methodology**

A survey design was adopted for data gathering. Inferential and descriptive statistics were used to analyse quantitative and qualitative data on the impact of tourism on the ecosystem was adopted. Information was obtained directly from the study area through observation and the use of questionnaire. Units for the measurement of independent and dependent variables for the study were the five point summative rating scale as follows: Strongly Agree (5), Agree (4), Neutral (3), Disagree (2) and Strongly Disagree (1).

The population of study included the tourists (who were identified and purposively sampled); and the coastal dwellers (purposively sampled from 25 villages) who themselves are stakeholders and beneficiaries (positive or negative) of the outcome of tourism and its activities. The population of 93,378 is drawn from 24 out of the 25 villages in Ibeno LGA as presented in Table 1. Extracted from the National Population Census of 1991 and projected to 2022, using the formula given as $Pt = Po(1+r/100)n$ .....Equation (1)

Where: Po = Based population (1991population), n = Number of years (32years) r = Population growth rate for rural communities in Akwa Ibom State (2.83%), Pt = Current population to be determined, 1 = Constant

Two sets of variables (X and Y) were identified based on review of literature related to the study. The X-(Tourism) is a set of independent variables and Y- (degree of conservation of resources) is a set of dependent variables.

i. Independent Variables

X1-Waste disposal facilities, X2-Religious/ traditional/cultural display, X3-Museum, X4-Nature Watching, X5-Canoeing, X6-Horse Riding, X7-Beach Balling, X8-Swimming, X9-Sun bathing, X10-Trekking, X11-Golf Playing, X12 -Guided Tours, X13-Security , X14-Hair Dressing Services, X15-Banking Services, X16-Hotel, X17 -Means of Transportation, X18-Internet Facilities, X19-Convenience Facilities, X20-Restaurant, X21-Markets, X22-Grocery Stores, X23-Jetties/ Harbours, X24-Clinic, X25-Electricity, X26-Portable Water Supply, X27-Accessibility to Site

ii. Dependent Variables

Y1-Salt Marsh Conservation, Y2-Sandy Beach Conservation, Y3-Bay/Island Conservation, Y4-Sand flat/Mud Flat Conservation, Y5-Lagoon and Estuary Conservation, Y6-Flood Plain Conservation, Y7-Sea Weed Conservation, Y8-Seafood/ Wildlife Conservation, Y9-Mangrove Conservation.

Table 1: List of study population as Projected Population from 1991 Census Figures to 2022

S/N	Villages	Population (1991)	Projected population (2022)	Number of households	Proportional Sample Size	Quasi Proportional Sample Size
1	Akata	667	1498	250	7	10
2	Atabrikang	850	1909	318	8	10
3	Atia	729	1637	273	7	10
4	Esuk Ikim Akwaha	663	1489	248	7	10
5	Esuk Ikim Ekeme	359	883	147	4	10
6	Ijung Abasi Okure	2391	5370	859	24	24
7	Ikot Inwang	1844	4142	690	18	18
8	Inua Eyet Ikot	334	750	125	3	10
9	Itak Idim Ekpe	514	1154	192	5	10
10	Itak Idim Ukpa	287	645	108	3	5
11	Itak Ifaha	259	582	97	3	10
12	Itio Esek	1788	4016	669	18	18
13	Iwo Okpom	654	1469	245	6	10
14	Iwo Okpom Opolom	1566	3517	586	15	15
15	Iwuoachang	4985	11190	1865	49	49
16	Mkpanak	6746	1552	2525	66	66
17	Ndito Eka Iba	2695	6053	1008	27	27
18	Ntafre	124	280	47	1	10
19	Okom Ita	1137	2554	426	11	11
20	Okorutip	1223	2747	458	12	12
21	Okposo l	2551	5730	955	25	25
22	Okposo ll	1134	2547	425	11	11
23	Opolom	203	456	76	2	10
24	Ukpenekang	6892	15479	2580	68	68
	Total	40595	93,378	15208	400	400

Source: Extracted from National Population Commission (1991), projected by the researchers (2022)

The settlements were selected alphabetically using a sample frame which is formed from the study population. Also, there was a purposive sampling of the managers of the tourist centres, community leaders, youths, women, men, traditional rulers, shop/business owners, professionals, elites/ stakeholders and political leaders of the communities in Ibeno LGA. Furthermore, purposive sampling technique was used to select respondents from each of the villages and tourist centres in the study area.

Multiple Linear Regression Analysis (MLRA) technique was employed. This expressed the dependent variable as a function of the number of independent variables (Triantaphyllov, 2000). The MLRA) technique was used to determine if there is a significant relationship between tourism related factors and degree of conservation of coastal resources in Ibeno LGA. The regression model is given as follows:

Y. = a + b1x1+b2x2+b3x3 ……+bnxn+ e ..... Equation (2)

Where: y = degree of conservation of coastal resources, a = Regression constant, b1-bn = Regression co-efficient of the independent variables, x1-x3 = Independent variables (tourism related factors), e = Residual error (which reveals the strength of b1x1……..b3x3)

The multiple linear regressions on SPSS 20 was used to generate a wide range of statistics for significant variables in the analysis.

6.0 Data Presentation, Analysis and Discussion of Findings

The data on occupational profile of respondents, tourism potentials (coastal resources), the socio-economic and ecological impacts of coastal tourism are presented and analysed. A total of 464 copies of the questionnaire were administered but 442 or 95.3% response rate, were completed and returned.

6.1 Occupational Status of Respondents

Table 4 shows that 17.7% of the respondents were tourists, while 28.3% of them were public/civil servants and 54.0% of the respondents were trading/ doing business.

Table 4: Occupation of Respondents

S/No.	Occupation	Frequency	Percentage
A	Public/civil servants	125	28.3
B	Tourists	78	17.7
C	Trading/ Business	239	54.0
	Total	**442**	**100%**

Source: Authors' Field work, 2022

6.2 Coastal Resources (Tourism Potentials)

The coastal resources in the study area which are also tourism potentials and their importance to the Ibeno people are presented in Table 5. There are abundant seafood and wildlife as they rank 1st with 4.7 mean score. Salt Marsh ranks 2nd with a mean score of 4.5, while, Sandy beach and Sand flat rank 3rd with a mean score of 4.1. Flood plain ranks 4th with a mean score of 4.0 and the 5th on the ranking is mud flat with a mean score of 3.9. Also, Bay/ Island, Lagoon /Estuary and mangrove forest rank 6th apiece with a mean score of 1.9 each, while 1.7. Seaweed ranks 7th and last with a mean score of 1.6.

Table 5 also, shows the importance of these resources to the Ibeno people. According to the respondents, the resources as the sources of food rank 1st with a mean score of 4.6, while as sources of construction materials rank 2nd. The 3rd and 4th on the ranking are that the resources generate income and as well serve as dwelling places for community deities with mean scores of 4.5 and 4.4 respectively, while barrier to disaster comes 5th and last on ranking with a mean score of 1.7.

Table5: Coastal Resources (Tourism Potentials) and Their Importance to Ibeno LGA

Resources and Importance/ Villages	*Sea Food and Wildlife*	Mud Flat	Sandy Beach	Sea Weed	Bay/ Island	Flood Plain	Sand Flat	Mang rove forest	Lagoon and Estuary	Salt Marsh	Source of Food	Source of construc tion material	Gene -rate in- come	Dwelling place for deity	Barrier to disaster	Mean	Rank
Akata	4.9	3.9	4.3	1.3	1.5	4.7	4.7	1.4	1.8	4.7	4.9	4.8	4.6	3.7	1.3	**3.6**	**3rd**
Atabrikang	4.9	4.3	4.3	1.4	1.6	4.5	4.6	1.4	1.8	4.7	4.9	4.8	4.6	3.7	1.3	**3.6**	**3rd**
Atia	4.9	4.1	4.3	1.4	1.4	4.6	4.4	1.4	1.7	4.8	4.9	4.6	4.6	3.5	1.5	**3.6**	**3rd**
Esuk Ikim Akwaha	5.0	4.0	4.3	1.6	1.4	4.7	4.3	1.6	1.9	4.7	4.6	4.5	4.4	3.4	1.4	**3.5**	**4th**
Esuk Ikim Ekeme	4.9	3.9	4.5	2.0	1.5	4.6	4.5	1.7	1.9	4.7	4.3	4.8	4.5	3.4	1.7	**3.6**	**3rd**
Ijung Abasi Okure	4.6	3.7	4.2	1.4	1.7	4.1	4.3	1.9	2.2	4.4	4.1	3.8	3.8	3.5	2.2	**3.4**	**5th**
Ikot Inwang	4.8	4.1	4.3	2.3	4.5	4.4	4.1	2.0	1.8	4.4	4.6	4.3	4.2	3.3	2.3	**3.7**	**2nd**
Inua Eyet Ikot	4.5	2.1	4.7	1.2	1.8	1.6	1.8	1.4	1.3	4.0	4.6	4.4	4.5	3.6	1.7	**3.0**	**9th**
Itak Idim Ekpe	4.9	4.1	4.3	1.4	1.4	4.6	4.4	1.4	1.7	4.8	4.9	4.6	4.6	3.5	1.5	**3.6**	**3rd**
Itak Idim Ukpa	4.9	3.9	4.3	1.4	1.6	4.5	4.6	1.4	1.8	4.8	4.9	4.8	4.6	3.7	1.3	**3.6**	**3rd**
Itak Ifaha	5.0	4.0	4.3	1.6	1.4	4.7	4.3	1.6	1.9	4.7	4.6	4.5	4.4	3.4	1.4	**3.5**	**4th**
Itio Esek	4.6	3.8	3.8	1.9	1.7	4.0	4.1	1.9	1.8	4.4	4.7	4.4	4.0	3.7	1.8	**3.4**	**5th**
Iwo Okpom	4.6	3.7	4.2	1.4	1.7	4.1	4.3	1.9	2.2	4.4	4.6	4.4	4.5	3.6	1.7	**3.5**	**4th**
Iwo Okpom Opolom	4.8	4.2	4.5	1.5	1.7	4.5	3.7	1.5	1.5	4.5	4.7	4.4	4.4	3.5	2.0	**3.5**	**4th**
Iwuoachang	4.1	3.8	2.0	2.0	1.8	4.0	3.8	2.0	2.2	3.8	4.1	4.0	4.0	3.8	1.5	**3.2**	**7th**
Mkpanak	4.2	4.4	4.6	2.6	2.2	2.2	4.3	2.1	2.1	4.1	4.3	4.3	4.2	2.2	2.0	**3.4**	**5th**
Ndito Eka Iba	4.7	4.1	4.1	2.0	2.1	2.7	3.9	1.8	2.2	4.0	4.5	4.4	4.4	2.9	1.7	**3.4**	**5th**
Ntafre	4.9	3.9	4.3	1.3	1.5	4.7	4.7	1.4	1.8	4.7	4.9	4.8	4.6	3.7	1.3	**3.6**	**3rd**
Okom Ita	4.9	3.9	4.2	1.7	1.5	4.6	4.2	1.6	1.8	4.6	4.9	4.5	4.6	2.7	1.5	**3.5**	**4th**
Okorutip	4.9	3.9	4.3	1.4	1.6	4.5	4.5	1.4	1.8	4.8	4.3	4.8	4.5	3.4	1.7	**3.5**	**4th**
Okposo l	4.6	4.0	4.1	1.2	1.9	3.9	4.2	4.6	2.0	4.1	4.6	4.5	4.4	3.1	2.0	**3.5**	**4th**
Okposo ll	5.0	4.0	4.3	1.6	1.4	4.7	4.3	4.4	1.9	4.9	4.9	4.6	4.6	3.5	1.5	**3.8**	**1st**
Opolom	4.5	2.1	4.7	1.2	4.7	1.6	1.8	1.4	1.3	4.0	4.6	4.5	4.4	3.4	1.4	**3.1**	**7th**
Ukpenekang	4.2	4.5	1.4	2.5	1.9	4.3	4.2	1.9	2.1	4.3	4.4	4.2	4.1	2.0	2.1	**3.3**	**6th**
MEAN	**4.7**	**3.9**	**4.1**	**1.6**	**1.9**	**4.0**	**4.1**	**1.9**	**1.9**	**4.5**	**4.6**	**4.5**	**4.4**	**4.3**	**1.7**		
RANK	**1st**	**5th**	**3rd**	**7th**	**6th**	**4th**	**3rd**	**6th**	**6th**	**2nd**	**1st**	**2nd**	**3rd**	**4th**	**5th**		

6.3 Ecological Impact of Coastal Tourism

The ecological impact of coastal tourism as presented in Table 6 shows that biodiversity loss ranks 1st with a mean score of 4.6, while indiscriminate waste disposal ranks 2nd with a mean score of 4.5. Coastal erosion with a mean score of 4.1 ranks 3rd while pollution and impaired wetland rank 4th with a mean score of 4.0 each. Loss of mangrove ranks 5th with a mean score of 3.9, and vegetation loss ranks (6th) last with mean score of 2.3.

Table 6: The Ecological impact of coastal tourism

	Variables	Mean	Rank
a)	Coastal Erosion	4.1	3rd
b)	Indiscriminate waste disposal	4.5	2nd
c)	Pollution	4.0	4th
d)	Impaired Wetland	4.0	4th
e)	Biodiversity Loss	4.6	1st
f)	Flooding	4.1	3rd
g)	Vegetation Loss	2.3	6th
h)	Loss Of Mangrove	3.9	5th

Source: Authors' Work (2022)

6.4 Factor Analysis and Naming of Factors

Factor analysis technique was employed using data on 36 variables (27 independent variables and 9 dependent variables) gathered from the 24 villages. As a result, 6 factors for independent variables and 3 factors for dependent variables loaded as follows:

i.X variables which represent tourism are named: X1-Tourism Industry Factor: Banking Services, Hotel, Means of Transportation, Internet Facilities, Convenience Facilities, Museum, Horse Riding, Golf Playing, Restaurant, Grocery Stores, Jetties/ Harbours; X2-Tourism Services Factor: Religious/ traditional/cultural display, Sun bathing, Electricity, Hair Dressing Services, Portable Water Supply; X3- Tourism Infrastructure Factor: Beach Balling, Convenience Facilities, Restaurant; X4-Tourism Product Factor: Nature Watching, Markets; X5-Tourism Security Factor: Guided Tours, Security; and X6-Clinic/Accessibility to Site Factor: Clinic, Accessibility to Site.

ii.Y variables representing coastal resources conservation are named: Y1-Coastal Features Conservation Factors, Salt Marsh Conservation, Bay/Island Conservation, Lagoon/ Estuary Conservation, Flood Plain Conservation; Y2-Biodiversity Conservation Factor: Seafood/Wildlife Conservation and Mangrove Conservation; and Y3-Wetland Conservation Factor Sand Flat/ Mud Flat Conservation.

6.4.1 Tourism and Coastal Features Conservation Factor

Table 6 indicates that 77.9% (overall) of the variance in Coastal Feature Conservation can be predicted from the variables, industry factor, infrastructure factor, services factor and clinic/accessibility factor. It can be noted that, the predictor variable X1(Industry factor) has 42.6% association with dependent variable (Coastal Feature Conservation). Also, the predictor variables X1(Industry factor) and X3(Infrastructure) have 17.4% association with dependent variable (Coastal Feature Conservation), while the predictor variables X1(Industry factor), X3(Infrastructure) and X2(Services) have 11.0% association with dependent variable (Coastal Feature Conservation). More so, the predictor variables X1(Industry factor), X3(Infrastructure), X2(Services) and Clinic/accessibility factor have 6.9% association with dependent variable (Coastal Feature Conservation).

Table 6: Overall Model Fit for Coastal Features Conservation Factor

Model Summary[e]										
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.652[a]	.426	.400	.7748762	.426	16.306	1	22	.001	
2	.775[b]	.600	.562	.6618587	.174	9.155	1	21	.006	
3	.842[c]	.710	.666	.5779156	.110	7.544	1	20	.012	
4	.883[d]	.779	.732	.5173805	.069	5.954	1	19	.025	1.910

Source: Author's Compilation, 2021

a. Predictors: (Constant), X1(Tourism Industry Factor)

b. Predictors: (Constant), X1,X3

Tourism Industry Factor, Tourism Infrastructure

c. Predictors: (Constant), X1, X3,X2 Tourism Industry Factor, Tourism Infrastructure, Tourism Service

d. Predictors: (Constant), X1, X3, X2, X6 Tourism Industry Factor, Tourism Infrastructure, Tourism Service, clinic/accessibility factor.

e. Dependent Variable: Coastal Features Conservation Factor

From the regression result, the coefficient of determination (R^2) is given as 0.779, which shows that the explanatory power of the variables is high and/or strong. This implies that 77.9% of the variations in the Coastal Feature Conservation are accounted for or explained by the variations in the development of tourism industry factor, tourism infrastructure, tourism services and clinic/accessibility factors in the study area. While other independent variables not captured in the model explain 22.1% of the variations in the Coastal Feature Conservation.

Table 7: Parameter Estimates for Coastal Features Conservation Factor

Coefficients[a]									
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations		
		B	Std. Error	Beta			Zero-order	Partial	Part
1	(Constant)	.000	.158		.000	1.000			
	X1	-.652	.162	-.652	-4.038	.001	-.652	-.652	-.652
2	(Constant)	.000	.135		.000	1.000			
	X1	-.652	.138	-.652	-4.728	.000	-.652	-.718	-.652
	X3	-.418	.138	-.418	-3.026	.006	-.418	-.551	-.418
3	(Constant)	.000	.118		.000	1.000			
	X1	-.652	.121	-.652	-5.414	.000	-.652	-.771	-.652
	X3	-.418	.121	-.418	-3.465	.002	-.418	-.612	-.418
	X2	.331	.121	.331	2.747	.012	.331	.523	.331
4	(Constant)	.000	.106		.000	1.000			
	X1	-.652	.108	-.652	-6.048	.000	-.652	-.811	-.652
	X3	-.418	.108	-.418	-3.871	.001	-.418	-.664	-.418
	X2	.331	.108	.331	3.068	.006	.331	.576	.331
	X6	-.263	.108	-.263	-2.440	.025	-.263	-.488	-.263
a. Dependent Variable: Coastal Features Factor									

Source: Author's Compilation, 2021

Table 7 shows that tourism industry, tourism infrastructure, and clinic/accessibility factors have negative impact on Coastal Feature Conservation of the study area. This means that if these factors are developed, there will be decline in the conservation of coastal resources in the study area. On the other hand, tourism service has a positive impact on the conservation of coastal features in the study area. Thus, increase in tourism service will bring about improvement in the Coastal Feature Conservation of the study area.

6.5 Discussion of Findings

The results of the study reveal that there are many coastal resources in Ibeno LGA which also serve as tourism potentials. These resources include, sandy beach, salt marsh, bay/island, Lagoon/Estuary, flood plains, sea food/ wildlife, mud flat/sand flat, mangrove forest and seaweed. These resources are beneficial to the Ibeno people as they serve as sources of food and building materials; means of generating income, dwelling place for community deities and barrier to natural disaster. This agrees with the views of Eagles *et al*. (2002), Deng and Bauer (2002) and Duxbury and Dickinson (2007) that the beach is a unique environment endowed with resources and occupied by animals and plants. The Ibeno coastal communities have certainly benefited from tourism through the creation of employment opportunities, the raising of revenue, the development of infrastructure, improvements in health and safety conditions and enhancements of aesthetic standards. This is in line with the opinion of (Coccossis and Mexa, 2004) in tourism development. Loss of natural landscape, flora and fauna have been highlighted in this study. This can have dire consequences on local ecosystems as invasion foreign organisms tend to be particularly successful in colonizing disturbed areas where the local biotic communities have been affected and potentially harmed (Kertesz, 2009).

7.0 Conclusion

A cumulative link between tourism and the conservation of coastal resources in Ibeno LGA is revealed in the study. It is concluded that if tourism industry, tourism infrastructure, and clinic/accessibility factors are developed and improved in form of banking services, hotel, means of transportation, internet facilities, convenience facilities, museum, horse riding, golf playing, restaurant, grocery stores, jetties/ harbours, wildlife watching, convenience facilities, restaurant, banking services, clinic and accessibility to site; all of these will erode the natural environment. Therefore, in this research, the level of conservation of coastal resources in the study area as exposed by the findings is low.

8.0 Recommendations

Based on the findings, the following recommendation is therefore proffered: Sustainable/ecotourism is recommended for practice in the study area. This can be done by planned and controlled tourism development as well as integrated coastal management. This in turn will aid the conservation of the fragile coastal ecosystem and curtail the ever-increasing risk of environmental degradation as well as biodiversity loss.

References

Alipour, A. O., Maleki, H., Dalir, P. (2007). Perceptions of Beach Users: A Case of The Coastal Areas of North Cyprus Towards Establishment of A Carrying Capacity. Tourism Analysis, 12 (3) 175-190.

Altinay, M. and Hussain K. (2005). Sustainable Tourism development: a case of North Cyprus. *International Journal of Contemporary Hospitality Management.* 17 (3) 272-280.

Buckley, R. (2012). Sustainable Tourism: Research and reality. Annals of Tourism Research. 39 (2) 528-546.

Burke I. (2001).Pilot Analysis of Global Ecosystems: Coastal Ecosystems. Washington, DC, USA: World Resources Institute.

Clark, J. R. (1992), Integrated Management of Coastal Zones, FAO Fisheries Technical Paper, No. 327, Food and Agriculture Organization of the United Nations, Rome

Coccossis, H. and Mexa, A. (eds) (2004), The Challenge of Tourism Carrying Capacity Assessment: Theory and Practice, Ashgate, Aldershot.

Coccossis, H. and Nijkamp P. (1996) Sustainable Tourism Development.Avebury, England. ISBN 185972177X

Creel, L. (2003). Ripple Effects: Population and Coastal Regions. Population Reference Bureau. USAID MEASURE Communication Project.

Davenport, J. and Davenport, J.L. (2006). The Impact of Tourism and Personal Leisure Transport on Coastal Environments: A Review. Estuarine, Coastal and Shelf Science,67, 280-292.

Deng, J., King, B. and Bauer, T., 2002.Evaluating Natural Attractions for Tourism. Annals of Tourism Research, 29(2), 422–438.

Duxbury, M. and Dickinson, L. (2007). Principles for Sustainable Governance of the Coastal Zone: In the Context of Coastal Disasters. Ecological Economics, 63, 319-330.

Eagles, P. F. J., McCool, S. F. and Haynes, C. D. (2002), Sustainable Tourism in Protected Areas: Guidelines for Planning and Management, World Commission on Protected Areas (WCPA), Cambridge.

Earle, Sylvia, A. (1995).Sea Change, New York: Fawcett Columbia, USA.

Evans L., Cherrat N. and Pemsl D. (2011). Assessing the Impact of Fisheries Co-Management Intervention in Developing Countries: A meta-analysis. Journal of Environmental Management, 92 1938-1949.

Gill, A., D. Fennell, S. LeRoy and Dobell, R. (2003)Workshop backgrounders: 2003 OMRN national conference "Coastal Tourism". Halifax, NS, Canada: Ocean Management Research Network.

Goodhead T. and Johnson D. (1996). Coastal Recreation Management: The Sustainable Development of Maritime Leisure. London E and F.N. Spon.

Hall and Page (2006). The Geography of Tourism and Recreation: Environmental, Place and Space. London; New York: Rouledge.

Hughes P. (1994). Planning for Sustainable Tourism: The ECOMOST Project. International Federation of Tour Operators

Jennings, S. (2004). Coastal Tourism and Shoreline Management, *Annals of Tourism Research, 31(4) 899-922.*

Kertesz A. (2009). The Global Problem of Land Degradation and Desertification. *Hungarian Geographical Bulletin, 58 (1), 19-31.*

Kline, J. D. (2001). Tourism and Natural Resource Management: A General Overview of Research and Issues. Washington, DC, USA: United States Department of Agriculture.

Lawrence D.P. (2000).Planning Theories and Environmental Impact Assessment.Environ. Impact Assessment Rev. 20, 607–625

Mauz B., Fanelli F., Elmejdoub N. and Barbieri R. (2012). Coastal Response to Climate Change: Mediterranean Shorelines During the Last Interglacial (MIS 5) *Quaternary Science* Reviews 54, 89-98

Moghimehfar F. and Halpenny T. (2016). "How Do People Negotiate Through Their Constraints to Engage in Pro-Environmental Behavior? A Study of Front-country Campers in Alberta, Canada". Tourism Management, 57, 362–372.

Moss P. (2012). Impacts Of Late Quaternary Sea-level Changes On Coastal Environments of Eastern Queensland, Australia. *Abstracts/Quaternary International* 279-280, 233–345

Nicholls, R.J., Wong P.P., Burkett V.R., Codignotto J.O., Hay J.E., McLean R.F., Ragoonaden S. and Woodroffe C.D. (2007) Coastal Systems and Low-lying Areas.

NPC (1991) . National Population Commission of the Federal Republic of Nigeria .analytical Report at the National Level, NPC, Abuja. 29-31.

Ofem, B. I and Inyang, A. G. (2019). Stubb Creek Forest Reserve, Akwa Ibom State, Nigeria: How Donor Communities Fare Socio-economically. *Ethiopian Journal of Environmental Studies and Management* Vol.12, No. 1, pp 83-95. www.ajol.info/index.php/ejesm/index

Rouphael A.B., Abdulla A. and Said Y. (2011) A Framework for Practical and Rigorous Impact Monitoring by Field Managers of Marine Protected Areas. *Environmental Monitoring Assessment* 180, 557–572.

Silva, J. N. and Ghilardi-Lopez NP. (2012). Indicators of The Impacts of Tourism on Hard-Bottom Benthic Communities of Ilha Do Cardoso State Park (Cananeia) and Sonho Beach (Itanhaem), Two Southern Coastal Areas of Sao Paulo State (Brazil). Ocean & Coastal Management, 58, 1-8.

Sorice P. (2007)."Managing Scuba Divers To Meet Ecological Goals for Coral Reef Conservation". AMBIO: *A Journal of the Human Environment,* 36(4), 316–322.

Stern P. (2000) Toward a Coherent Theory of Environmentally Significant Behaviour. *Journal of Social Issues*.56 (30, 407-424.

Swaney D.P., Humborg C., Emeis K., Kannen A., Silvert W., Tett P., Pastres R., Solidoro C.,Yamamuro M., Hénocque Y. and Nicholls R. (2012). Five Critical Questions of Scale for The Coastal Zone. Estuarine, Coastal and Shelf Science 96, 9-21

Switzer A.D., Sloss C.R., Horton B.P. and Zong Y. (2012). Preparing for Coastal Change. *Quaternary Science Reviews* 54, 1-3

Triantaphyllov T. (2000). "Multi-Criteria Decision Making: An Operations Research Approach", Encyclopedia of Electrical and Electronics Engineering, (J.G. Webster, Ed.), John Wiley and Sons, New York, NY, Vol. 15, pp. 175-186, 1998.

Tuhin G. (2012). Sustainable Coastal Tourism: Problems and Management Options. *Journal of Geography and Geology,* 4 (1), 163-169

Udoh I. S. (2019). Hospitality of the People at the Tourism Destination and Destination Attractiveness of Akwa Ibom State, *Nigeria.International Journal of Research in Tourism and Hospitality (IJRTH)* Vol. 5, Issue 2, 2019, PP 1-7ISSN 2455-0043http://dx.doi.org/10.20431/2455-0043.0502001www.arcjournals.org

UNEP (United Nations Environment Programme) (1995), Guidelines for Integrated Management of Coastal and Marine Areas - With Special Reference to the Mediteranean Basin. United Nations Environment Programme Regional Seas Reports and Studies No. 161, Priority Actions Programme Regional Activity Centre (PAP/RAC) of the Mediterranean Action Plan (MAP - UNEP), Split.

Woodroffe C.D. and Murray-Wallace C. (2012). Sea-Level Rise and Coastal Change: The Past As A Guide To The Future. *Quaternary Science Reviews* 54, 4-11

World Tourism Organization (UNWTO) Tourism Highlights.(2016) Edition [internet]. Retrieved
WWF (2013), A Strategic Environmental Assessment of Fiji's Tourism Development Plan, World Wide Fund for Nature. WWF, Problems: Tourism & coastal development, World Wide Fund for Nature, Available at: http://www.panda.org/ (accessed in June 2020)

Yunis, E. (2006). Tourism in SIDS: A Key Factor for Economic, Social and Environmental Sustainability. London, UK: World Tourism Organization.

ASSESSMENT OF THE IMPLEMENTATION OF VALUATION STANDARDS AMONG PRACTICING ESTATE SURVEYING AND VALUATION FIRMS IN UYO, AKWA IBOM STATE

Emmanuel Okoror, Francis Nwanekezie, Iniodu Ibanga and Diana Eyoefen
University of Uyo, Uyo
Phone number: 07031241557, email: emmaokoror@gmail.com

ABSTRACT
This study assessed the implementation of valuation standards among practicing estate surveying and valuation firms in Uyo, Akwa Ibom State with a view to developing and initiating useful recommendations which would guide and improve the professional practice. It employed a survey research design. The sampled constituted all the estate surveying and valuation firms operating within the study area. Structured questionnaire was used to collect data for the study. The data collected were analysed using relative frequency tables, relative importance index (RII), severity index and standard mean deviation. Major findings deduced from the analysis showed that there was a significant level awareness of the NIESV valuation standards. Also, it was found that there was a low adoption of the use and application of this valuation standard. Besides, there was a low level of the extent of compliance in the implementation of the valuation standards among practicing surveying and valuation firms. Further, the availability of enforcement mechanism for the compliance of this valuation standards was low, and several factors such as lack of awareness of the existence of valuation standards, lack of understanding on how the valuation standards operate, inadequate enlightenment on the need to adopt valuation standards in practice, among others were observed to have influenced the smooth implementation of valuation standards among respondents. Deducing from the findings, the study recommended that the regulatory body of the estate surveying and valuation practice in Nigeria should carry out a high level awareness and sensitization programme with regards to the implementation of valuation standards so as to ensure that practicing surveyors and valuers have the needed knowledge and information about the valuation standards and its importance. Also, practicing estate surveyors and valuers should ensure total compliance to the regulatory body overseeing the practice of estate surveying and valuation so as to enhance their professional skills and technique. More so, the regulatory body should carry out continual checks so as to ensure that the already-mentioned factors which hinders the smooth implementation of valuation standards are given adequate attention and consideration with a view of ensuring better practices and optimum delivery to the clients.

Introduction

Over the years, countries of the world have defined and set the standards of financial reporting in their individual territories. More importantly, globalization has brought about an ever-increasing need for collaboration, international trade and commerce among the countries of the world. Hence, there is grave need for increased uniformity in the standards guiding financial statements so that such statement would remain comprehensible and convene the same information to users across the world. Advantageously, Nwanekezie (2018) and Nwanekezie (2009) opined that this would lead to clients and carrier satisfaction. Similarly, there has also been an increased awareness in recent times of the urgent need to improve valuer's methodology and practice along national, regional and international boundaries. This has been informed by the growing demand on the side of clients who can no longer accommodate inaccurate valuation advice, but instead are requiring sophisticated investment advice (Gilbertson and Preston, 2005 and Ogunba and Ajayi, 2007) . This buttresses the fact that strategic valuation relevance in modern investment decision often requires accurate sales and acquisition advice, among others. Thoughtfully, Harvard (1995) reported that without accurate valuations, investment in property cannot be reliable and efficient (Millington, 1988 and Ajayi, 2003). Therefore, one would acknowledge that the act of valuation is an inexact science largely because it depends on individual valuers' expertise, training, intuitional judgment, and underlying assumptions, and these attributes needful be focused on achieving accuracy. Therefore, this position coupled with the complexities of the property market in which practicing estate surveyors and valuers operate and the unique characteristics of the property market gives rise to valuation inaccuracies. As such, valuation standards are required to assist practicing estate surveyors and valuers in their process of value estimation so as to enable them arrive at a more transparent and objective opinion of market value.

Globally, valuation standards are established and accepted procedural rules, ethics and guidance for practicing estate surveyors and valuers during their conduct of valuation practices (Ogunba and Ajayi, 2007). It is a summary of best practices and generally established criteria that are recognised and acceptable by a regulatory body of practicing estate surveyors and valuers to guide their valuation practice, making it accurate, effective and transparent. In the words of Ajayi (2009), valuation standards are quality control principles for practicing estate surveyors and valuers under the direction of a regulatory body on how to undertake and report valuation practices. Based on this position, emphasis on valuation standards has assumed greater prominence in the last quarter of the 20th century as a result of the financial debacle which has been traced to property-related transactions (Gilbertson and Preston, 2005). These financial crises began in the United Kingdom in the early 1970s and were followed by the United States of America saving and loan crisis in 1980s. Added to this crisis was that the United Kingdom property market also collapsed in the 1990s. All these property and financial crises were partly attributed to poor quality of valuations reports used to secure bank loans in these countries (Gilbertson and Preston, 2005 and Dugeri *et al.*, 2012). This prompted the establishment of valuation standards at various levels in Europe and United States. Among the foremost in existence is the International Valuation Standards otherwise known as the "White Book", produced by the International Valuation Standards Council (IVSC), and has a universal adoption status.

Back here in Nigeria, there is an increasing concern over the quality of valuation practice among practicing estate surveyors and valuers as asserted by Gambo (2010) and Babawale (2008). Based on this assertion, Udo-Akagha (1985) earlier posited that "there ought to be no reason why two or more practicing estate surveyors and valuers valuing the same interest in a property for the same purpose and at the same time should not arrive at the same or similar results if they make use of the same data and follow the same valuation approach". In the same vein, many Nigerian scholars have concluded that contemporary valuation practices are not a good indicator for market value due to inaccuracy (Ogunba, 1998; Ajibola, 2006 and Babawale, 2011). Hence, the implementation of valuation standards is a major effort to address the problem of inaccuracy in valuation practice. From another perspective, Ajayi (2009) concluded that since the International Valuations Standards Council is not a regulatory body, it cannot enforce valuation standards. Therefore, the responsibility of enforcing standards by way of sanction or any similar action must be done by the representatives of the regulatory bodies of individual countries, or by self-regulating professional organizations. This concern raised thought-provoking questions such as what are the recommendations to both practicing estate surveyors and valuers and their regulatory body could be suggested to enable the implementation of valuation standards in the study area?

Notably, the few studies probing the quality of valuation practices in Nigeria have only addressed the subject of valuation standards in part and based their studies on Metropolitan Lagos (Ogunba and Ajayi, 1998; Ogunba and Ajayi, 2000; Babawale and Koleoso, 2006; Ogunba and Ajayi, 2007; Babawale, 2008 and 2012). In addition to that, none of these earlier studies considered the actual implementation of these valuation standards. Although the previous studies are timely pointers to the need to close the gap in the face of globalisation, suffice it to say that the width and depth of the study required to budge valuation practice in Nigeria to meet the world order and put it in a state of global competitiveness is beyond the scope of a short paper, rather requires wider coverage and depth (Ajayi, 1990, and Ogunba and Ajayi, 2007). It is against the foregoing that this study intended to undertake an all-inclusive study assessing the implementation of valuation standards among practicing estate surveying and valuation firms in Uyo, Akwa Ibom State and the enforcement measures put in place by the regulatory bodies in Nigeria to ensure compliance.

Review of Related Literature

The Need for the Implementation of Valuation Standards in Professional Practice

Valuation being an art and a science requires the judgment of a practicing estate surveyor and valuer who must apply some scientific processes in market value estimation. Harvard (1995) described valuation practice as an inexact science which makes the process of market value estimation dependent on the practicing estate surveyor and valuer's knowledge and interpretation of trends in the property market place. More so, the heterogeneous nature of the property market in which these properties exist and their unique attributes couple with the differences in individual perception, intuitive judgment and

training makes market value estimation to the practicing estate surveyor and valuer a daunting task. It is therefore pertinent to assist practicing estate surveyor and valuer in their process of market value estimation to arrive at an accurate opinion to enhance client's satisfaction. This is the whole essence of valuation standards.

On this backdrop, valuation standards should contain basic underlying concepts and principles of market value which are the tenets of any practicing estate surveyor and valuer, and should aid him in achieving any given valuation practice. More so, another essence of valuation standard implementation should be to ensure that practicing estate surveyors and valuers would achieve a high standard of integrity, clarity and report these valuations in accordance with the required bases appropriate for the purpose (Babawale, 2012a). According to Mills (2007), a primary purpose of setting valuation standards at international level is to facilitate cross-border transactions, contribute to the viability of international property markets, promote transparency in financial reporting, promote accuracy of valuations reports and serve as a professional benchmark to other practicing estate surveyor and valuer, globally. Valuation standards such as those enshrined in the Royal Institution of Chartered Surveyors (RICS) Red Book, TEGOVA's Approved European Property Standards, and IVSC's Standards, however, contain mandatory and non-mandatory guides to be implemented by its members during valuation practices (RICS, 2010 and IVSC, 2011). Therefore, the need for valuation standards is closely linked to IVSC's focus on increasing the confidence of valuation clients. In fact, their overriding objectives for providing valuation standards are to promote accuracy and aid practicing estate surveyor and valuer's understanding of all types of valuation practice. This they have achieved by identifying or developing globally accepted principles and definitions; identifying and promulgating common principles for the undertaking of valuation practices and reporting of valuation; identifying specific matters that require consideration and methods commonly used when valuing different types of assets or liabilities; identifying the appropriate valuation methodology and reporting disclosures for the major purposes for which valuations are required; reducing diversity of practice by enabling the convergence of different valuation standards used in specific sectors and stages of each country (IVSC, 2011).

Notably, valuation standards are provided to be applied by practicing estate surveyors and valuers with the intention of benefiting clients of valuation services and regulate market operations generally. RICS (2010) also reaffirmed that valuation standards are to provide as an effective regulatory framework within the rules of conduct so that clients of valuation practice could have confidence that a valuation report provided by any practicing estate surveyor and valuer is not only in accordance with internationally recognised valuation standards, but also that there is an obligation placed on the practicing estate surveyor and valuer to implement these standards. Similarly, unprecedented court litigations have also impelled the need for valuation standards. Sampson *et al.* (1988) observed that the courts have always looked up to the published standards for professional bodies to guide their judgements. These standards have aided the courts to establish liability cases in negligence and fraud. Fernandez (2006) maintained that valuation standards are important as they aid practicing estate surveyor and valuer display high levels of integrity and competence. They also serve as gauge for the duty of care exhibited by practicing estate surveyor and valuer to their clients since the report contains the code of ethics, enunciation of principles of valuation practices supported by outline of best practices. Unarguably, valuation practices carried out based on specifications of the standards is a good defence when a practicing estate surveyor and valuer is challenged in a court of law, on charges of negligence. More so, the client may institute action against the practicing estate surveyor and valuer for any claim where it is established that the he did not comply with valuation standards. It is to this end that valuation standards are important to the practicing estate surveyor and valuer in dispensing his duties.

Awareness and Compliance to Valuation Standard

The profession of estate surveyors and valuers in Nigeria is still at its growing stages when compared to that of Britain, United States, and Europe, among others (McNamara, 1999). However, the Estate Surveyors Registration Board of Nigeria (ESVARBON) and Nigeria Institution of Estate Surveyors and Valuers (NIESV) has been established by government through enabling laws to regulate the profession of estate surveying and valuation in Nigeria. This includes among others the setting and implementation of valuation standards within its professional membership. To achieve this fact, the regulatory body has adopted the Nigeria Guidance Note aligned in context with the International Valuation Standard and

the International Accounting Standard as shown in its S8. Particularly, this section emphasizes the need to adhere to all sections of the International Valuation Standard Code of Conduct pertaining to ethics, competence and disclosure reporting. Further, the note has enabled NIESV to establish faculties reminiscence of the RICS. These faculties are mandated to hone members' skill in their respective areas and promote specialization. More so, it has mandated that every practicing estate surveyor and valuer who desires to render valuation practices to public entities in Nigeria must be duly registered with the Financial Reporting Council as well as International Reporting Standards, International Public Sector Accounting Standards, International Standard on Accounting, Global Investment Performance Standards and the International Valuation Standard. All these actions show that awareness by both government and practicing estate surveyor and valuers are available.

Dynamics of the Regulatory Framework of Valuation Standard

Worthy to note, regulatory bodies play an important role in ensuring that practicing estate surveyors and valuers should conform to acceptable valuation standards in their discharge of professional duties. To this end, they are concerned with issues pertaining to ethics, best practices, research development, and the enforcement of rules and regulations guiding the profession, among others, all this are enshrined in their guidance note. For example, since the 16th century, the professional body in United Kingdom (RICS) have regulated activities of practicing estate surveyor and valuer through their "Red Book" (RICS, 2010). The published standards have been changing with circumstances required along with the dynamic economic environment. When there was bank disquiet in the early 1990s, the RICS joined with the British Banking Association (BBA) in a concerted effort which resulted in the publication of new valuation guidelines on bank lending in 1994 (RICS, 1994). The RICS valuation department also initiated another research in 1994 through the Mallinson Committee which resulted in the publication of the first unified mandatory valuation standards which was issued in 1995.

With this purview, French (2003) remarked that the RICS valuation standards (the Red Book) is an evolving document and in the last ten years the profession has produced a number of reports that have influenced and structured the changes that have been incorporated in the manual. RICS series of revised editions have included those published in 1976, 1981, 1990, 1995, 2003, 2007, 2008, 2010 and 2012. More so, RICS is affiliated to the European Group of Valuers Association (TEGOVA) which is a regional standard setting body, and also to the International Valuation Standards Council (IVSC), which has 52 member states (RICS, 2003). The International Valuation Standards Council has been attuning to investors' sophistication to enable it provide a proper code of conduct and practical information to achieve high professional best practices. Now, the increasing demand in the business and financial world requiring valuations are carried out in accordance with International Accounting Standards compelling the IVSC to promulgate standards by ensuring that valuations undertaken by members would enable investors to measure and compare their investment performance in the property market. (Fernandez, 2005). The International Valuation Standards Council has also published standards in its 1985, 1995/97, 2000, 2001, 2003, 2005, 2007, 2009 editions and the latest edition, now in 2011. Many commonwealth countries of the world such as Nigeria have aligned their country's guidance note in line with "the Red Book".

In Nigeria, the first Guidance Notes on Property Valuation was published by the Nigerian Institution of Estate Surveyors and Valuers (NIESV) in 1985. This was probably influenced by the development unfolding in the United Kingdom about the same time. The second edition which has close semblance with the 6th edition of the International valuation Standards was published in 2006. Since then there has been no further revisions of the NIESV Valuation Standards and Guidance Notes. However, the subsisting guidance note is in conformity with professional practice.

Form and Contents of Valuation Standard Manuals

There are categories of valuation standards at international, regional and national levels. The International valuation standard is setup by the International Valuation Standards Council (IVSC) which is a global standard known as the "White Book". The International Valuation Standard Council is concerned with developing global standards for real estate, personal property, financial and business interests. The International Valuation Standards (IVS) are frequently being updated with its current edition in 2014. The International Valuation Standards produced by IVSC is not mandatory for

implementation in practice by estate surveyors and valuers around the world and they do not have to adhere to its provision except where their national valuation standards incorporate aspects of it and make it mandatory.

The IVSC does not have power to enforce on members but can enforce through adoption in the national standards. Regional valuation standards include the European valuation standards produced by The European Group of Valuers' Association (TEGOVA) known as the "Blue Book". The European Valuation Standard is produced for practicing surveyors and valuers that are members of the 45 valuers' association from 26 countries representing the membership of TEGOVA (TEGOVA Blue Book, 2012). The Uniform Standards of Professional Appraisal Practice (USPAP) is produced by the Appraisal Standards Board of the Appraisal Foundation (TAF) for practicing surveyors and valuers in the United States of America and Canada. This standard has a regional status as it applies outside the United States of America and extends to Canada and some Asian countries.

The valuation standards manual produce by the Royal institution of Chartered Surveyors (RICS) known as the "Red Book" is meant to be a national standard for the United Kingdom but has gained the status of a regional standard because it is of its influence across the globe, in particular Commonwealth countries (Fernandez, 2006). The Australia and New Zealand valuation and property standards set by Australian Property Institute (API) is a national standard that came into effect on 1st August 2006 with the latest edition produced in 2012. The Guidance Notes and Valuation Standards produced by the Nigerian Institution of Estate Surveyors and Valuers (NIEVS) is a national standard which operates within Nigeria. The Nigeria's standards were first published in 1985 and revised in 2006, since then nothing is done about it. The NIESV valuation standard is like a fragmented portion of the 2003 International Valuation standards produced by the IVSC. The contents of valuation standards carry along with its professional considerations with the practical needs of the market place (Babawale, 2013). The essence of the standard is to impose sanctions or serve as advisory or combination of the two. Worthy of note is the fact that it is only regional or national valuation standards that can enforce compliance. This is done through appropriate professional regulatory bodies whose jurisdiction covers a region or nation. However, Babawale (2013) opined that standards could be imposed by personal conscience, by national professional institutions or by law. Valuation standards are not necessarily concerned with valuation theory and methodology but are concerned with mechanics of practice including assembly, interpretation and reporting of information relevant to any valuation assignment (RICS, 2003). In the light of the foregoing, Edge (2002) made a distinction between valuation standards and methodology in that methodologies are dynamic, changing with need, fashion, demand, and analytical techniques borrowed from the fields; standards should be consistent, a benchmark of good practice. IVSC, 2003; 2014, a typical valuation standard manual contains at least three parts these are – the standards, the application, and the guidance notes and commentary.

The standards section addresses issues related to valuation bases and reporting among others. The application section focuses on application of the standards to business and financial interests and valuation for lending purposes, while the Guidance Notes focus on specific valuation issues and commentary of business and service producing situations. Complimentary sections provide the glossary of terms, short discussions on valuation principles and techniques, history and recent developments. The IVSC (2014) has an introductory section with three broad sections. The Introductory section covers principal changes to previous edition of the standards, International Valuation Standards (IVS) definitions, and International Framework.

The first section is General Standards which covers Scope of Work (IVS 101), Implementation (IVS 102), and Reporting (IVS 102). The second section of the most recent valuation standards is Asset Standards which captures Business and Business Interests (IVS 200); Intangible Assets (IVS 210); Real Property Interest (IVS 230); Investment Property Under Construction (IVS 233); and Financial Instruments (IVS 250). The third section is Valuation Application which covers Valuation for Financial Reporting- Property, Plant and Equipment in the Public Sector (IVS 300); and Valuation of Real Property Interest for Secure Lending (IVS310). Some regional and national standards contain codes of professional ethics and enforcement procedures for appropriate sanctions in the event of material breach.

RESEARCH METHODOLOGY

Research Design

A survey research design using descriptive method was considered most appropriate to collect experienced opinion of practicing estate surveyors and valuers in the study area. The design was best suited to the studies as it aimed at investigating the assessment of the implementation of valuation standards among practicing estate surveying and valuation firms in Akwa Ibom State.

Research Population and Sample Size

Mugenda and Mugenda (2003) defined a population as a complete set of individuals, cases or objects with some common observable characteristics. This is a group of members of persons as to which a researcher is willing to generalize the result of the research study. The population of this study was the registered estate surveying and valuation firms in Uyo, Akwa Ibom State where a principal of each firm was sampled and made up the respondents.

The practicing estate surveyors and valuers are the ones authorized to carry out valuations in the Federal Republic of Nigeria under the Estate Surveyors and Valuers Registration Act (otherwise known as Decree 24 of 1975) now Cap E13 LFN 2007. Estate surveyors and valuers in the public sector were excluded as they are proscribed by the code of ethics from carrying out valuations for private consultation. The research population included 54 estate surveyors and valuers practicing in different estate surveying and valuation firms operating within Uyo, Akwa Ibom State.

Sample Size

From the directory of estate surveyors and valuers in Akwa Ibom State, 2020, there are a total of fifty-four (54) estate surveying and valuation firms in the State having different category of professional's membership as Fellows, Associates Above 10years, Associates Below 10years, Probationers, and Graduate Members of NIESV. Hence, a total of 54 estate surveying and valuation firms were used in this research, each firm having one principal member sampled and made up the respondents. These set of respondents were professionals whose inputs were relevant in the study.

Sampling Design

Sampling design refers to the technique or the procedure the researcher would adopt in selecting some sampling units from which inference about the population could be drawn (Kothari, 2004). It was determined before any data was collected.

In this study, 54 estate surveyors and valuers were sampled and the choice of incorporating them in the study area was that they were the most appropriate officers possessing relevance knowledge in assessing the implementation of valuation standard. The research instrument (questionnaire) was administered on each respondent estate surveyor and valuer. Nevertheless, the purpose of the study was clearly explained to the respondents with assurance that their responses would be treated with strict confidence, and used for academic purpose only.

Instrument for Data Collection

Questionnaire was developed and used for the study. It covered several sections including background information on the years of experience in practicing estate surveying and valuation, investigating the level of awareness to the valuation standards as set up by the regulatory board, identification of any compliance measures available to the practicing estate surveyors and valuers and implementation of adequate measure to ensure compliance. This was to assess the knowledge based on their involvement in the administration and regulation of estate surveying and valuation practice in Nigeria. The data collected from the research was as a result of the willingness and high level of compliance.

Copies of the questionnaire were administered on the practicing estate surveyors and valuers' firms within the study area. The questionnaires addressed issues pertaining to the awareness of valuation standards, the type of valuation standards implemented by the practicing surveying and valuation firms, the extent of compliance and the factors that hindered the implementation of valuation standards. It ensured that questions posed to the respondents were uniformly phrased, thus permitting objective comparison of results. The intention was to frame questions in the form of a questionnaire as required

by the respondents. The questionnaire was structured into different sections with items as it addressed all the objectives of the study.
From the directory of the estate surveyors and valuers' professional body (NIESV) in Akwa Ibom State, there are 54 practicing estate surveying and valuation firms operating within Uyo, Akwa Ibom State. Consequently, questionnaires were administered to each principal partner or his representative.

Technique of Data Analysis
In order to attend to the stated objectives listed in this work, the method adopted to analyse each of the objectives was shown in Table 1.

Table 1: Technique of Data Analysis

S/N	Objectives	Type of Data Required	Measurement Scale	Method of Analysis
1	Evaluate the level of awareness of Valuation Standards among Practicing Estate Firms.	Information was gathered from practicing estate surveyors and valuers in the study area.	Ordinal Scale	Relative Importance Index (RII).
2	Ascertain the valuation standards in use by practicing estate surveying and valuation firms.	Information was gathered from practicing estate surveyors and valuers in the study area.	Nominal Scale	Frequency Distribution
3	Determine the extent of compliance with valuation standards by practicing estate surveyors and valuers' firms.	Information was gathered from practicing estate surveyors and valuers in the study area.	Ordinal Scale	Relative Importance Index (RII).
4	Examine enforcement measures available to the regulatory bodies in Nigeria to ensure compliance by practicing estate surveyors and valuers.	Information was deduced from Estate Surveyors and Valuers Registration Board of Nigeria (ESVARBON).	Nominal Scale	Questionnaire
5	Investigate factors influencing the implementation of valuation standards in the study area.	Information was gathered from practicing estate surveyors and valuers in the study area.	Ordinal scale	Questionnaire and Severity Index (SI)
6	Initiate possible recommendations to enable the adoption and adherence to valuation standards in valuations practices in the study area.	Researchers observation	Nominal scale	Researchers Recommendation

Source: Author's Compilation (2021)

DATA PRESENTATION, ANALYSIS AND DISCUSSION OF RESULTS
Level of Awareness of Practicing Estate Surveying and Valuation Firms on Valuation Standard

The first objective addressed the level of awareness of practicing estate surveyors and valuers have about valuation standards. Hence, a couple of valuation standards, are enumerated and responses availed by the respondents in line with their perception. Consequentially, a Likert scale provided a respondent ranking from 1 to 5 in a descending order. From the crux, 5 = Fully Aware, 4 = Aware, 3 =Fairly Aware, 2 = Unaware and 1 = Indifference and analysed using the Relative Importance Index Analysis as in Table 2.

Table 2: **Analysis of the Level of Awareness Practicing Estate Surveying and Valuation Firms has about Valuation Standards**

S/N	Valuation Standards	5	4	3	2	1	N	SUM	MEAN SCORE	RII	RANK
I	NIESV Valuation Standards	24	16	2	0	0	42	190	4.52	0.904	1st
Ii	IVSC International Valuation Standards (White Book)	22	13	4	3	0	42	180	4.29	0.858	2nd
Iii	RICS Red Book (UK)	19	15	8	0	0	42	179	4.26	0.852	3rd

Iv	TEGoVA Blue Book (Europe)	16	18	2	4	2	42	168	4.00	0.800	4th
V	USPAP by The American Foundation (TAF) in US and Canada	12	18	5	5	2	42	159	3.79	0.758	5th
Vi	Property and Valuation Standards by Australian Property Institute	10	13	8	7	4	42	144	3.43	0.686	6th

Source: Author's Analysis (2021)

Table 2 showed the result of the respondents' opinion with respect to their level of awareness of the valuation standards in the study area. It could be seen that the respondents were more aware of the following Valuation Standards - NIESV Valuation Standard, IVSC International Valuation Standard (White Book), TEGOVA (Europe) Blue Book respectively. However, since almost all the valuation standards were above the required 4.00 mean score (0.800RII), it showed that the respondents are much aware of some of the valuation standards. The result also showed that three of the variables scored below the 4.0 mean score (0.800RII) in the outcome which means that the respondents are not aware of them; they were TEGOVA Blue Book, USPAP by the American Foundation and the Property and Valuation Standards by Australian Institute.

Ascertain the Valuation Standard in use by Practicing Estate Surveying and Valuation Firms

The second objective sought to examine the valuation standard in use by the practicing estate surveying and valuation firms as presented in Table 3. This was achieved by summarizing the perception and views of the respondents from the interview schedule guide on which of the valuation standards is frequently in use by the respondents in the study area.

Table 3: Valuation Standard in Use by Practicing Estate Surveying and Valuation Firms

S/N	Aspect of Valuation Standards	Frequency	Percentage (%)
i.	Guidance Notes on special valuation, assumption and approaches to value	14	33.3
ii.	Minimum Reporting Content (scope of work)	10	23.8
iii.	Valuation Applications (e.g. financial reporting)	7	16.6
iv.	Basis of Valuation	5	11.9
v.	Investigations (verification of information)	4	9.5
Vi	Glossary (Definition of terms)	2	4.8
	TOTAL	**42**	**100**

Source: Author's Analysis (2021)

Table 3 showed the valuation standards in use by the estate surveyors and valuers firms, it shows that the Guidance Notes on special valuation, assumption and approaches to value records the highest percentage value of 33.3%, followed by the minimum reporting content (scope of work) as the highest use aspect of valuation standard use by estate surveyors and valuers, while Glossary (definition of terms) records the lowest percentage scores indicating the least application of valuation standards by practicing estate surveyors and valuers.

The Extent of Compliance with Valuation Standards by Firms of Estate Surveyors and Valuers in Practice

The third objective addressed the extent of compliance with valuation standards by firms of estate surveyors and valuers in practice within the study area. In attempt to address this objective, the statistical mean was adopted to ascertain the acceptance or otherwise of the questionnaire item. An item was only accepted if it scored at least 2.5 on the four-point scale mean value (x). Items which scored below 2.5 were rejected. In order to achieve this analysis, a Likert scale was provided the respondent ranking from 1 to 4 in a descending order. From the crux, 4 = Very High, 3 = High, 2 = Low and 1 = Very Low. The analysis of the collated data presents the result in Table 4 below.

Table 4: Extent of Compliance with Valuation Standards

S/N	Valuation Standards	4 VH	3 H	2 L	1 VL	SUM	∑FX	X
i.	NIESV Valuation Standards	30	12	0	0	42	156	3.71
ii.	IVSC Valuation standard and Guidance notes	20	12	8	2	42	134	3.20
iii.	Determine and adopt the most appropriate basis of valuation that is compatible with the purpose of valuation for coherence and transparency.	32	10	0	0	42	158	**3.76**
iv.	Valuation application for financial reporting and valuation of real property interests for secured lending.	42	0	0	0	42	168	4.00
v.	Fully adoption of Property and Valuation Standards by Australian Property Institute among investors	0	6	16	20	42	70	1.66
vi.	Assets standards in interest , tangible assets, plant and equipment and real property and financial instruments.	18	22	2	0	42	140	3.33
vii.	USPAP by The American Foundation (TAF)in US and Canada	8	10	12	12	42	98	2.33
viii.	Adoption of General Standard on the scope of work, implementation and reporting.	12	20	10	0	42	116	2.76
ix.	Using of TEGOVA's blue book for fair value in accounting	0	0	8	32	42	48	1.14
	Average							**2.88**

Source: Field Survey (2021)

Table 4 revealed that there is a degree to the extent of compliance at an average mean score of 2.88 which is slightly above the minimum point of 2.5 on the scale, being 0.38 points away from the unacceptable or insignificant point.

Examine the Enforcement Measures Available to the Regulatory Bodies to Ensure Compliance with Valuation Standards

The fourth objective examined the enforcement measures available to the regulatory bodies to ensure compliance with valuation standards in the study area. In order to address this objective, germane information was deduced from the directory of the professional practice committee of the Estate Surveyors and Valuers Registration Board of Nigeria (ESVARBON) by requesting them to highlight the enforcement measures predominantly adopted to ensure the compliance with valuation standards by estate surveyors and valuers in practice. The data obtained are thus enumerated in the Table 5.

Table 5: Enforcement Measures Available to the Regulatory Bodies in Nigeria

S/N	Enforcement Measures
1	Admonishment
2	Reprimand
3	Severe Reprimand
4	Public Censure in writing
5	Financial Penalties (Fine)
6	Restricted Practice (under supervision)
7	Suspension
8	Expulsion (Deregistration)
9	Onward Prosecution

Source: Field Survey (2021)

Table 5 revealed that there are enforcement mechanisms set aside by the regulatory bodies to ensure that practicing estate surveyors and valuers in firms comply with the laid down standards. However, the available measures were to admonishment, reprimand, financial penalties, suspension, expulsion and onward prosecution.

Factors Influencing the Implementation of Valuation Standards in the Study Area

The fifth objective investigated factors influencing the implementation of valuation standards in the study areas. In order to address this objective, a couple of factors which were determinants in the implementation of valuation standards were deduced from the appropriate respondent. This was done by the use of interview schedule thus a couple of factors were enumerated. These factors were availed the respondents from which their responses was thus analysed in line with their perception. Consequentially, a Likert scale was provided to enable the ranking from 1 to 5 in a descending order. From the crux, 5 = Strongly Agreed, 4 = Agreed, 3 = Indifferent, 2 = Disagree and 1 = Strongly Disagreed. This objective is analysed in Table 6 below, in sync with the perception of the respondents using the Severity Index analysis of perceptual factors that influences the adoption and implementation of valuation standards.

Table 6: Factors that Influence the Implementation of Valuation Standards

S/N	Factors/Variables	5	4	3	2	1	N	SUM	SI	RANK
I	Lack of awareness of the existence of valuation standards.	24	16	2	0	0	42	190	4.52	1st
Ii	Difficulty in understanding how the standards operate.	22	13	4	3	0	42	180	4.29	2nd
Iii	No enforcement measures on use and compliance in practice	19	15	8	0	0	42	179	4.26	3rd
Iv	Inadequate enlightenment on the need to adopt valuation standards in practice	16	18	2	4	2	42	168	4.00	4th
V	Inadequate training on the use of valuation standard	12	18	5	5	2	42	159	3.79	5th
Vi	Compromise of standards by estate surveyors and valuers to gain jobs and appease their clients.	10	13	8	7	4	42	144	3.43	6th
vii	Apathetic attitude of estate surveyors and valuers towards adoption of valuation standards in practice	5	13	12	10	2	42	135	3.21	7th
viii	The valuation standards do not fully reflect the peculiarities of our market	3	7	8	9	15	42	100	2.38	8th
Ix	The practice is not complex enough to make use of valuation standards	1	5	10	12	14	42	93	2.21	9th
X	The Nigerian valuation standards is not practicable	0	2	8	13	19	42	77	1.83	10th
									3.39	

Source: Authors Data Analysis (2021)

Table 6 showed that the first to seventh ranking factors were significant, having a Severity Index above 3.00 (mean point). The 8th, 9th and 10th variable have an index score of less than 3.00 (mean point) revealing that they factors/variables weren't significant. However, a more thorough examination of the analysis revealed that some factors were more important than others. The factor with the highest significance level as identified in the above table was 'lack of awareness of the existence of valuation standards' with index of 4.52, and is ranked 1st. All the other factors follow the ranking in an order from

the most severe (ranked 1st) to the least severe (ranked 10th). From the table illustration above, taking an average of the SI is 3.39 which is above the mean point, therefore it was significant.

Discussion of Results

Findings from objective one showed that a significant number of the estate surveying and valuation firms in Akwa Ibom State have awareness on the valuation standards while many were yet to come to the realization of the existence of valuation standards in practice. It was discovered that the awareness was majorly on some international valuation standards like the NIESV valuation standard followed by the IVSC International Valuation standard (White Book) and the RICS valuation standards (Red Book). The study also revealed that a significant number of practicing estate surveyors and valuation firms only merely heard of valuation standards while some are yet to come to know its existence. This was in agreement with the work of Babawale and Ajayi (2011) on the level of awareness of valuation standards among estate surveyors and valuers in Nigeria. Their findings also revealed that there was awareness of valuation standards among practicing estate surveyors and valuers, but many are yet to come this realization.

Findings from analysis of objective two revealed that significant numbers of the respondents make use of the valuation standards ranging from the guidance notes on special valuation assumption and approaches to value followed by minimum reporting content being the scope of the valuation work, valuation application and financial reporting, basis of valuation, investigation and verification of information and definition of terms. Though the extent to their use and application of valuation standards varied, whiles some aspect of valuation used by the respondent recorded highest percentage, others valuation standards like the glossary (definition of terms) recorded the least percentage scores implying that its application or use is not often like others as recorded in the frequency table. It was also realized that many practicing estate surveying and valuation firms in the study area merely applied the valuation standards while some percentage of the respondent rarely applied some of the valuation standard. This result was inconsistent with the work of Babawale (2018) who examined the application of valuation standards among practicing estate surveyors and valuers in Lagos Metropolis. He observed that many estate surveyors and valuers do not make any reference to the application of valuation standards.

Findings from objective three showed that many practicing estate surveyors and valuers to a certain extent complied with the international valuation standards, while a significant number were yet to come to the realization of this standards and their level of compliance was insignificant. However, there were compliance on the preliminary aspects of valuation reporting, adoption of the more appropriate basis of valuation was compatible with the purpose of valuation for coherence and transparency, adoption of general standard of scope of work implementation and reporting, NIESV Valuation Standard among others. This further showed that practicing estate surveyors and valuers firms rarely complied with the valuation standard. This study was supported by the work of Onyeneke (2013) who assessed the compliance of the Nigerians valuation practice to international valuation standard in Port Harcourt. His findings revealed that practicing estate surveyors and valuers had complied with the valuation standards.

Findings from objective four revealed that there were measures made available by the regulatory bodies for the enforcement of valuation standards. These provisions for enforcement measures made were admonishment, reprimand, imposition of penalties and fines, suspension, expulsion from practice and onward prosecution. This study was also backed by the work of Oluwatobi (2018) who examined the factors militating against the implementation of valuation standards in Nigeria, he also presented the relevance of International Valuation Standard (IVS) as they applied in the use of investment method methods of valuation in Nigeria. His finding revealed that appropriate enforcement measures and sanction should be meted on a practicing estate surveyor and valuer who refuses to comply with the valuation standard.

Findings from objective five revealed that there were considerable numbers of factors that influenced the implementation of valuation standards in the study area and as such impeded the level valuation practices and hindered their operations in the practice of estate surveying and valuations. These factors were identified as lack of awareness of the existence valuation standards, lack of understanding on how the standing operate, inadequate enlightenment on the need to adopt valuation

standards in practice, no enforcement on the use and compliance in the valuation standard in practice, inadequate training on the use of valuation standards, compromise of standards by valuers to gain jobs and to appease clients, apathetic attitude of practicing estate surveyors and valuers towards adoption of valuation standards in practice, the valuation standards does not fully reflect the peculiarities of our market, the practice is not complex enough to make use of valuation standards and the Nigerian valuation standards is not practicable.

Conclusion

This study was able to analyse the data obtained from the fieldwork and attain an appropriate conclusion from the results of major findings. It was established the level of estate surveyors and valuer's awareness to valuation standards was more attuned to the NIESV Valuation book than any other. With regards to the application of valuation standards in practice, estate surveyors and valuers practicing within the study area used it for guidance notes, etc. It further concluded that the extent of compliance of the valuation standards was more attuned to the NIESV valuation book. The study also established factors that influenced the implementation of valuation standards such as lack of awareness of the existence of valuation standards, among others.

Recommendations

From the findings, the study recommended that the regulatory body of the estate surveying and valuation practice in Nigeria should carry out a high-level awareness and sensitization on the available valuation standards. This is pertinent so as to ensure that practicing surveyors and valuation would have the needed knowledge and information about the valuation standards and its importance. Hence, it would ensure a better and accurate valuation practice. Also, the Estate Surveyors and Valuers Registration Board of Nigeria (ESVARBON) and the Nigerian Institution of Estate Surveyors and Valuers (NIESV) professional body should ensure continuous and persistent training and encourage research on the different aspect of valuation standards so as to ensure competency in use of the valuation standards. With this, practicing estate surveying and valuation firms should ensure total compliance to the regulatory body overseeing the practice so as to enhance the professional skills and technique of their staffs. Therefore, practicing estate surveyors and valuers should be pro-active in attending conferences, workshops, symposia, mandatory continuous professional development trainings and other similar workshops where skills are enhanced and developed. Further, the responsibility of enforcement lies with the professional regulatory body, hence, a functional valuation standard that makes compliance mandatory is required to provide enforcement and sanctions. They should also come up with an all-inclusive, pragmatic and up-to-date valuation standard with peculiarities to the local market should incorporate adequate enforcement measures for sanctioning erring estate surveyors and valuers who fail to comply with existing standards. The regulatory body should carry robust checks to ensure that factors that hinder the smooth implementation of valuation standards are given adequate attention and consideration to ensure better practice while ensuring optimum delivery to the clients.

REFERENCES

Adegoke, O. J. and Aluko, B. T. (2007). Heuristic Behaviour in Valuation Practice in Lagos Metropolis. *The Estate Surveyor and Valuer,* 30(1): 5-12.

Adegoke, O.J., Olaleye, A. and Oloyede, S. A. (2011). A Study of Valuation Clients' Perception on Mortgage Valuation Reliability. *The Estate Surveyor and Valuer,* 35(1): 89-96

Adewunmi, Y. A. (2014). *Benchmarking Practice in Facilities Management in Selected Cities in Nigeria*, Unpublished Ph.D. Thesis of the Department of Estate Management, University of Lagos, Akoka, Yaba, Lagos, Nigeria

Adjekophori, B., Okpaleke, F., Omorogieva, D. E. and Emaghe, I. J. (2014). Valuers' Enlistment and Fees Standardization Practice in Nigerian Banking Industry: Implication for Real Estate Profession. 15th African Real Estate Society (AFRES) Annual Conference, 2-5 September, Cape Town, South Africa.

Ajayi, C. A. (1994). Conventional Versus Contemporary Valuation Approaches. Paper Presented at the Annual Guest Lecture of Osun State Branch of the Nigeria Institution of Estate Surveyors and Valuers (NIESV), 10 October

Ajayi, C. A. (1997). Towards a New Direction for Property Valuation Practice in Nigeria, *The Estate Surveyor and Valuer,* 20(10): 20-27.

Ajayi, C. A. (2003). The Income to Valuation: Paper presented at MCPD workshop to Osun State Branch of the Nigerian Institution of Estate Surveyors and Valuers, October 10th.

Ajayi, C. A. (2006). *Towards a New Direction for Property Valuation Paradigm*. A. O. ; S. A. Daramola; C. A. Ajayi; O. A. Ogunba; and K. T. Odusami (Eds.) In the Built Environmet, Innovation, Policy and Sustainable Development, Covenant University, Ota, Ogun State, Nigeria

Ajayi, C. A. (2009). International Valuation Standards as Applicable in the Use of the Investment Methodof Valuation and in Mortgage Valuation. Valuations in the Residential Property Market in Lagos. *The Estate Surveyor and Valuer, 21* (2), *7-17*

Ajayi, C.A. (1990). *An Analysis of Default Factors in Residential Mortgages of the Federal Mortgage Bank of Nigeria and Oyo State Property Development Corporation*, Ile-Ife: Unpublished Ph.D Thesis of the Department of Estate Management, Obafemi Awolowo University.

Babawale, G. K. (2005). The Challenge of Globalisation for Property Valuation Profession in Nigeria. *Globalisation, Culture and the Nigerian Built Environment.1*, pp. 41-45. Ile-Ife, Nigeria: Faculty of Environmental Design and Management, Obafemi Awolowo University.

Babawale, G. K. (2007). Valuers' Liability for Negligence. *The Estate Surveyor and Valuer,* 30(1): 49-55.

Babawale, G. K. (2008). An Evaluation of Factors Influencing Valuation Accuracy in Residential Property Valuation in Lagos Metropolis, Unpublished Ph. D Thesis of the Department of Estate Management University of Lagos, Akoka, Yaba, Nigeria.

Babawale, G. K. (2013). Toward a Standardized Approach to Real Estate Valuation Practice in Nigeria. A Paper Presented at the Mandatory Continuous Professional Development of Nigerian Institution of Estate Surveyors and Valuers, Ogun Sate Branch, Nigeria, October 6.

Babawale, G. K. and Ajayi, C. A. (2011). Variance in Residential Property Valuation in Lagos, Nigeria, *Property Management,* 29(3): 222-237.

Babawale, G. K., and Koleosho, H. A. (2006). Real Estate Valuation Practice in Nigeria: Implications in a Globalising World. *The Built Environment, Innovation, Policy and Sustainable Development* (pp. 301-306). Ota, Nigeria: Dept. of Architecture, C.S.T, Covenant University, Canaan Land.

Babawale, G.K. (2012a) An Assessment of the Current Standard of Real Estate Valuation Practice in Nigeria. *Eloxir Soc. Sci. 47:9094-9102*. www.elixirjournal.org (Retrieved July 16, 2012)

Babawale, G.K. (2012b) Paradigm Shift in Investment Property Valuation Theory and Practice: Nigerian Practitioners' Response. *Mediterranean Journal of Social Sciences, 3(3):217-228*

Baum, A. and Crosby, N. (1995) *Property Investment Appraisal* International Thomson London: Business press

Baum, A., Crosby, N., Gallimore, A. and McAlister, P.(2000). "The Influence of Values and Valuations on the Workings of the Commercial Investment Property Investment Market". Report for the Education Trusts of the Investment Property Forum, Jones Lang LaSalle and the Royal Institute of Chartered Surveyors London.

Beccaria, C. (1963). *On Crimes and Punishment*. H. Paolucci (Ed.). New York: MacMillan

Becker, C. and Manstetten, R (2004). Nature as You: Novalis Philosophical Thought and the Modern Ecological Crisis, *Environmental Values*, 13: 101-118

Becker, G. S. (1968). Crime and Punishment: An Economic Approach. *Journal of Political economics*, 76(2):169

Bello, O. M. (2009). International Valuation Standards and Valuation Practice in Nigeria. *Mandatory Continuing Professional Development Programme* (pp. 1-6). Ikeja, Lagos: NIESV Lagos State Branch.

Bello, O. M. and Bello, V. A. (2007). The Influence of Contemporary Models of Valuation Practice in Nigeria. Strategic Integration of Surveying Services, FIG Working Week, Hong Kong, SAR, China 13-13 May

Brekke, K. A. and Howarth, R. B. (2002). *Status, Growth and Environment: Goods as Symbols in Applied Welfare Economics*, Cheltenham: Edward Elgar Publishing,

Crosby, N. (1991). Reversionary Freeholds: UK Market Valuation Practice. Research report of The Royal Institution of Chartered Surveyors (RICS), 1-27

Crosby, N. (2000) Valuation Accuracy, Variation and Bias in the Contex of Standards and Expectations. Journal of Property Investment Finance, 18(2): 130-161

Crosby, N., Laver, A. and Murdoch, J. (1998b). Property Valuation and the Margin of Error. *Journal of Property Research. 15(4):305-33*

Crosby, N., Lavers, A., and Murdoch, J. (1998a). Property Valuers and Appraise Liability Exposure: An International Perspective on Negligence in Valuation. Retrieved from www.prres.net/.../_Propery_Valuers_Appraisers,_Liability

Curry, B. (2002). Neural Networks and Non-linear Statistical Methods: An Application to the Modelling of Price Quality Relationship, *Computers and Operations Research*, 29(8): 951-969

Dawson, C. (2002). *Practical Research Methods, a User-Friendly Guide to Mastering Research,* Oxford, United Kingdom: How to Books

Deaconu, A., and Buiga, A. (2010) Analysis of the Convergence Degree between the Accounting Standards and the Valuation Standards concerning Fair Value. *Journal of Property Investment and Finance*, 28(5): 365-384

Dugeri, T. T. (2011). An Evaluation of Nigerian Property Market Maturity, Unpublished Thesis, Department of Estate Management, University of Lagos, Akoka, Nigeria.

Dugeri, T. T., Gambo, Y. L., and Ajayi, C. A. (2012). Internalising International Valuation Standards: Relevant and Applicability Issues in the Nigerian Context. *ABTU Journal of Environmental Technology*, 5(1): 100-116.

Edge, J. A. (2002): The Globalization of Real Estate Valuation, FIG XXII International Congress Washington, D.C. USA, April 19-26 2002 http://www.fig.net/events/fig_2002/fig_2002_abs/Js24/JS24_edge_abs.pdf

Ellis, T. (2001). U.S and International Valuation Standards- The Future. SME 2001 Annual Meeting, Denver, Colorado, February 26-28

Ellis, T. (2002). Mineral Property Valuation Standards: A U.S Perspective. South African Institute of Mining and Metallurgy's Valuation Code Colloquium, Johannesburg, South Africa, March 19-20

Eriksson, C. (2005). Harmonization of Investment Valuation Standards in Europe. *Journal of Real Estate Literature*, 13(1): 46-64.

Estate Surveyors and Valuers Registration Board of Nigeria (2012) *Official Bulleting*, ESVARBON, Nigeria

French, N. (1996) Investment Valuation Developments from the Mallinson Report. *Journal of Property Valuation and Investment, 14(5): 48-58*

Gambo, Y. L. (2010). An Investigation into Quality of Valuation Practice Among Estate Surveyors and Valuers in Bauchi State, A Paper Presented to Nigerian Institution of Estate Surveyors and Valuers (NIESV), Bauchi Branch, 11th February, Bauchi, Nigeria

Gambo, Y. L. (2014). Response of Nigerian Valuers to International Valuation Standards Application: How Far the Journey? *The Estate Surveyor and Valuer, 39 (2): 89-98*

Gambo, Y. L. and Anyakora, M. I. (2013). Margin of Valuation Error Among Nigerian Valuers: Postulating an Acceptable Limit, *ATBU Journal of Environmental Technology, 6 (1): 54-65*

Gayen, A. K. (1951). The Frequency Distribution of the Product Moment Correlation Coefficient in random Samples of any Size Drawn from Non-Normal, *Biometricka, 38: 219-248*
Houses and Buildings, 9th Edition, London: Estate Gazette

Ifediora, B. U. (2005). *Valuation Mathematics for Valuers and other Financial and Investment Analysts*, Enugu, Nigeria: Immaculate Publications Ltd.

Ifediora, G. S. A. (2010). *Professional Practice: A Course Book and Road Map for Estate Surveyors and Valuers*, Enugu, Nigeria: Providence Press Ltd.

Igboko, P. (1992). *Research Project on Valuation Models in Nigeria with Special Reference to Y. P.* Lagos: NIESV.

International Valuation Standards Committee. (2001). International Valuation White Paper: Valuation in Emerging Markets, IVSC London.

International Valuation Standards Committee. (2002, January). Canadian Endorsement for International Valuation Standards. *Global Valuation Issues*: 6-6

International Valuation Standards Committee. (2002, September). Fair Value Accounting is the accepted model. *Global Valuation Issues:* 1-9

International Valuation Standards Committee. (2003). *International Valuation Standards.* London: International Valuation Standards Committee

International Valuation Standards Committee. (2005). *International Valuation Standards.*7th Edition London: International Valuation Standards Committee

International Valuation Standards Committee. (2007). *International Valuation Standards.* London: International Valuation Standards Committee.

International Valuation Standards Committee. (2011). *International Valuation Standards.* London: International Valuation Standards Committee.

International Valuation Standards Committee. (2014). *International Valuation Standards.* London: International Valuation Standards Committee.

Jaccard, J., Becker, M. A. and Wood, M. A. (1984). Pair Wise Multiple Comparison Procedures: A Review, *Psychological Bulletin, 96 (3): 589*

Jacoby, J. E. (1994). *Classics of Criminology*, Prospect Height, IL: Waveland.

Jain, R, Yadov, O., and Rathore, A. (2008). The Propagation of Benchmarking Concepts in Indian Manufacturing Industry. *Benchmarking: An International Journal,* 15(1): 101-117.

Janssen, C., Soederberg, B. And Zhou, J, (2001). Robust Estimation of Hedonic Models of Price and Income for Investment Property, *Journal of Property Investment and Finance,* 19(4): 342-360

Johnson, T., Davies, K. and Shapiro, E. (2000). *Modern Methods of Valuation of Land,*

Kauko, T. and D' Amato, M. (2004). *Mass Appraisal Valuation Methodologies: Between Orthodoxy and Heresy*, 11th European Real Estate Society Conference (ERES), Milan

Keynes, J. M. (1936). *The General Theory of Employment, London*: John Wiley

Krejcie, R. V. and Morgan, D. W. (1970). Determining Sample Size for Research Activities, Educational *and Psychological Measurement, 30: 607-610.*

Krippendorff, K. (1980). *Content Analysis: An Introduction to its Methodology*, Newbury Park, California: Sage Publications

Krosnick, J. A. and Presser, S. (2010). *Handbook of Survey Research, (2nd edition*), United Kingdom: Emerald Group Publishing Ltd.

Kumar, R. (1996). *Research Methodology: A Step-by-Step Guide for Beginners*. New Delhi: Sage Publications.

Larson, J. (2003). *Real Estate Principles and Practice*, New Jersey: John Wiley.

Lawson, J. W. W. (2008*). Theory of Real Estate Valuation*: Unpublished M.Sc. Thesis, School of Economics, Finance and Marketing, Royal Melbourne Institute of Technology

Lorenz, D. P. (2002). *International valuation standards and the impact of IAS and Basel II on property valuation standards and practice in Germany and in the UK*, A Text of Paper School of Economics and Business Engineering, University Fridericiana of Karlsruhe

Lorenz, D. P. (2006). The Application of Sustainable Development Principles to the Theory and Practice of Property Valuation: Unpublished PhD Thesis, School of Economics and Business Engineering, University Fridericiana of Karlsruhe

Lucius, D. L. (2001). Real Option in Real Estate Development, *Journal of Property Investment and Finance*, 19(1): 73-78

Lusht, K. M. (1997). *Real Estate Valuations Principles and Applications*, New York: Irwin

Lynch, B. K. (1996). *Language Program Evaluation: Theory and Practice.* Cambridge: CUP

Mackmin, D. And Emary, R. (2000). The Assessment of Worth: The Need for Standards. *Journal of Property Investment and Finance*, 18: 52-65.

Malaquin, P. (1997). The Role of Property Valuation Standards, 7th World Valuation Congress, Amsterdam, June.

Mallison Report (1994). Commercial Property Valuations, Royal Institution of Chartered Surveyors, London

Mansfield, J. R. and Lorenz, D. R. (2004). The Impact of Evolving International Accounting Standards on Valuation Practice in the UK and Germany. *Property Management*, 22(4): 289-303.

Map of Akwa Ibom (2015). www.mapofworld.com-nigerianmap

Mark, J. and Goldberg, M. A. (2001). Multiple Regression Analysis and Mass Appraisal: A Review of the Issues, *The Appraisal Journal, Jan., 89-109*

McParland, C., McGreal, S., and Adair, A. (1997). European Valuation Methodology and Techniques: Looking towards a Commonality in Approach. *Cutting Edge*, UK: RICS Research.

McParland, M., McGreal, S. and Adair, A (2000) Concepts of Price, Value and Worth in the United Kingdom – Towards a European Perspective *Journal of Property Investment and Finance. Vol. 18, 84-102.*

Newell, G. (2004) Assessing Professional Valuation Practice standards. *Australian Property Journal.*

Nigerian Institution of Estate Surveyors and Valuers (2006) *Valuation Standards and Guidance Notes*, Abuja, Nigeria: The Nigerian Institution of Estate Surveyors and Valuers

Nigerian Institution of Estate Surveyors and Valuers (2014) *The Directory of the Estate Surveyors and Valuers*, Abuja, Nigeria: The Nigerian Institution of Estate Surveyors and Valuers

Nunan, D. (1999). *Research Methods in language Learning. Eight Printing*. Cambridge: CUP

Nwana, O.C. (1981). *Introduction to Educational research for Students-Teachers*, Ibadan: Heinemann Educational Books, (Nig.) Ltd.

Nwanekezie, F. O., (2018). A Study of Career Satisfaction among Estate Surveyors and Valuers in Akwa Ibom State, Nigeria. THE ARTIST JOURNAL (TAJ) Volume. (2):37-42.

Nwanekezie, F. O., Ifekalam, I.C, and Diala, O.A. (2009). An Assessment of Client Satisfaction with the Services of Estate Surveyors and Valuers in the Niger Delta. Abia State University Environmental Review, 7(1): 77-95.

Ogunba, A. O., and Ajayi, C. A. (1998). An Assessment of the Accuracy of Valuation in the Residential Property Market of Lagos. *The Estate Surveyor and Valuer, 21* (2), 19-23.

Ogunba, O. (1997). A Study of Valuation and Pricing Methods in the Residential Property Market in Lagos Metropolis. Unpublished M.Sc. Dissertation, Department of Estate Management, Obafemi Awolowo University, Ile-Ife.

Ogunba, O. A, and Ajayi, A. C. (2000). A Critique of the Conduct of Valuation in Lagos Metropolis: Contemporary Issues in Real Estate, *Journal of Contemporary Issues in Real Estate*, 4:7-16.

Ogunba, O. A, and Ajayi, A. C. (2005). Globalisation and Professional Institutions: Challenges to the Nigeria's Real Estate Profession. *Globalisation, Culture and the Nigerian Built Environment. I.* Ile-Ife: Faculty of Environmental Design and Management, Obafemi Awolowo University.

Ogunba, O. A, and Ajayi, C. A. (2007). The Response of Nigerian Valuers to Increasing Sophistication in Investors' Requirements. *Journal of Property Investment and FInance,* 25(1): 43-61.

Ogunba, O. A. (2013). *Principles and Practice of Property Valuation in Nigeria*. Atlantis Books, Ibadan, Nigeria

Ogunba, O. A. And Iroham, C. O. (2010). A Search for an Acceptable Margin of Valuation Error: A Case Study of Valuers and their Clients in Nigeria, Sri Lanka Journal of Real Estate, 54-73.

Ogunba, O. A., Ajayi, C. A. and Aluko, B. T. (2005). Substitution Versus Anticipation: A Resolution of the Nigerian Valuation Practice Paradox, *Journal of Land Use and Development Studies,* 1(1): 1-10.

Ogunba, O., and Ojo, O. (2007). Resolving Reliability, Consistency and Rationality Problems of Professionally Prepared Valuations in Nigerian Practice. *The Estate Surveyor and Valuer, 30* (1), 39-48.

Ojo, B., and Bello, M. O. (2005). Globalisation and Real Estate Market in Nigeria. In W. Fadare, A. Ajayi, D. Amole, and B. Babalola (Eds.), *Globalisation, Culture and the Nigerian Built Environment.1*: 52-57. Ile-Ife: Faculty of Environmental Design and Management, Obafemi Awolowo University.

Oluwatobi, A. O. (2012). Use and Implementation of Valuation Standards in Lagos. Unpublished M. Sc. Dissertations, Department of Estate Management, Covenant University, Ota, Ogun State.

Otegbulu, C. A. (2001). Asset Valuation Standards and the Depreciation Problem. Paper Presented at the Estate Surveyors and Valuers Registration Board of Nigeria (ESVARBON), Lagos, Nigeria, May 29-30

RICS (2000) Appraisal and Valuation Manual (the "Red Book") March, 2000 update. London: Royal Institution of Chartered Surveyors

RICS (2002) *Carlsberg Review Committee Report*. London: Royal Institution of Chartered Surveyors

RICS (2012). RICS-Professional Standards (Red Book): Incorporating the International Valuation Standards, London: Royal Institution of Chartered Surveyors

RICS (2014). RICS-Professional Standards (Red Book): Incorporating the International Valuation Standards, London: Royal Institution of Chartered Surveyors

Royal Institution of Chartered Surveyors (1998) Appraisal and Valuation Manual (the "Red Book"), London: Royal Institution of Chartered Surveyors

Royal Institution of Chartered Surveyors, RICS (1994, 1995) Appraisal and Valuation Manual (the "Red Book"), Royal Institution of Chartered Surveyors: Westwood Business Park, UK

Sanni, L., and Akinyemi, F. V. (2009). Determinants of Households Residential District Preferences within Metropolitan City of Ibadan, *Journal of Human Ecology*, 25(2): 137-141.

Schnaidt, T. and Sebastian, S. (2012). German Valuation: Review of Methods and Legal Framework. *Journal of Property Investment and Finance,* 30(2): 145-158.

Seliger, H. W. and Shohamy, E. (1989). *Second Language Research Methods*. Oxford: OUP

The Nigerian Institution of Estate Surveyors and Valuers. (2006). *Valuation Standards and Guidelines of the Nigerian Institution of Estate Surveyors and Valuers.* Abuja: NIESV.

Thornes, C. (2007). Paper concentrated on Valuation Standard: Are We Doing it Right? *A paper by Vice Chairman, IVSC Standards Board presented at the 5th International Conference on the Valuation of Plant, Machinery and Equipment.* London. October 1-3.

Trifornov, N. (2009). Valuation in Modern Condition in Europe and in the World, Paper Presented at the 16th Annual European Real Estate Society Conference in Stockholm, Sweden

Udo, G. O. (2003). *Model Building in Property Valuation*, Enugu, Nigeria: Institute for Development Studies, University of Nigeria

Udo-Akagha, S. (1985) Guidance Note on Property Valuation Forward to the Nigerian Institution of Estate Surveyor and Valuers 1st Edition.

Vella, J. (2009). A Vision for Valuation: Building Valuation Standards. *Winter 2009 Edition for Property World, A publication of the RICS (Royal Institution of Chartered Surveyors).*

DYNAMICS OF INLAND SWAMPS AND SOCIO-ECONOMY OF ITU LOCAL GOVERNMENT AREA, AKWA IBOM STATE, NIGERIA

Beulah I. Ofem and Udeme E. Bassey
Department of Urban and Regional Planning, University of Uyo, Uyo
beulahofem@uniuyo.edu.ng 08023180512

Abstract
The study examined the effects of the changes of inland swamps on the socio-economy of Itu Local Government Area, Akwa Ibom State. Stratified sampling technique was employed to select twenty-three communities for the study. With the aid of questionnaire and satellite imageries, data were obtained. Descriptive statistical tools such as tables, percentages and graphs; and Pearson Product Multiple Correlation analysis were used. Findings showed that inland swamps are used for farming, fishing, recreation and for water transportation. The trend of swamp changes in the study area shows that within 30 years (1989 -2019), there was a gradual decrease in swamp size in Itu LGA. Factors like road construction, settlement expansion, resource exploitation activities, over exploitation of resources, changes in rainfall pattern and temperature were critical drivers of the change in swamp environment which impacted the socio-economics of the study area. Results further showed that socioeconomic variables like occupational changes, number of educational establishments, dominant occupational activities and educational attainment were significantly influenced by the swamp changes over time. Based on the findings, it is recommended that the rate of use and harvest of swamp resources should be done in line with the concept of wise use and sustainable development. Database of swamp resources use and harvesting should be created for proper trend study. EIA should be conducted before implementing development projects, to avoid negative impact road construction, settlement expansion, exploitation activities and over exploitation of timber may have on inland swamp.
Keywords: *Dynamics, Inland swamps, Socio-economy, Wetland ecosystem*

1.0 Introduction

Swamps are forested wetlands and those that are inland are termed inland swamps. Swamps are often found near rivers or lakes and have mineral soils that drain very slowly. Unlike mashes, they have trees and bushes. They may have water in them for a whole year or for only a part of the year. Some swamps are former lakes or ponds overtaken by trees and shrubs. Fresh water swamps for instance, form around lakes and streams. Rain and seasonal flooding cause water levels in swamps to fluctuate. They have outgrowth of trees' root systems. Swamps and wetland ecosystem are characterised by mineral soils with poor drainage and plant life dominated by trees. The latter characteristic distinguishes a swamp from a march, in which plant life consists of largely grasses. Swamps are found throughout the world **(**National Geographic Society, 2018; Encyclopaedia Britannica, 2021).

Inland swamps serve as fish nurseries and breeding grounds for finfish, crabs, shrimps, molluscs, and other marine lives. Equally, the ecosystem remains a source of valuable resources essential for the livelihood and survival of indigenous coastal people, which may include: sea food; fuel wood, construction materials, medicines, soaps, honey, oils, and tannins (Nagelkerken, 2002; Aburto-Oropeza, 2008). Vast quantities of fallen leaves and swamp mangroves branch detritus provide food for countless tiny marine creatures at the bottom of the global ocean food chain. These ecosystems are the greatest and often the only protein sources for millions of traditional communities worldwide (Aburto-Oropeza, 2008). Inland swamp are also essential habitats for many endangered species such as manatees, alligators, Bengal tigers and dark headed cuckoo (Aburto-Oropeza, 2008).

The benefits of the inland swamp ecosystems to surrounding habitats and communities are enormous. The several functions they provide include inundation control, protection from erosion, storm, floods, and wave damage, recreation and tourism, and generate tangible products such as fish, shellfish and forest materials. Their proximity to the coastline makes them good water filters, improving water quality and protecting habitats, such as coral reefs from siltation (Murray *et al.*, 2011; Salem and Mercer, 2012). The ability of swamp to sequester and store huge amounts of carbon plays an important role in global carbon budgets and in the process of mitigating climate change (Herr *et al.*, 2012). Hence, they are globally recognised as one of the three key 'blue carbon' habitats and are among the most carbon-rich forests in the tropics. They are able to sequester 6 to 8 tonnes of carbon dioxide equivalent

per hectare per ye ar (Murray *et al.*, 2011). These rates are about two to four times greater than rates observed in mature tropical forests (Wilkie and Fortuna, 2003). The adaptation encompasses a large number of different plants families.

According to Duke *et al.* (2007) the swamp forests once covered more than 200,000 km^2 of sheltered tropical and subtropical coastlines, but are gradually disappearing worldwide at approximately 1 to 2% per year. This rate is perhaps greater than or equal to declines in adjacent coral reefs or tropical rainforests. These losses are occurring in almost every developing country, where more than 90% of the world's swamps are found (Duke *et al.*, 2007). The decline of the swamp resource is linked to the rapid population growth and urbanization, high level of poverty, low development indices, poor governance in both urban and rural areas and open access of coastal resources, dredging and sand filling for swamp reclamation, road construction, industrial development in coastal areas and coastal resorts. The ecosystem threats also arise from coastal erosion, oil pollution, gas flaring, and subsidence of the coastal geosynclines aggravated by fluid withdrawal (oil and gas) from porous reservoirs in subsurface Niger Delta (UN Environmental Program, 2007; Arokoyu and Mom, 2010).

Itu Local Government Area (LGA) of Akwa Ibom State in the Niger Delta region of Nigeria is easily identified with inland swamps that are either salt water swamps, made up of mangrove ecosystem or fresh water swamps. Moving away from the basin where the forest communities are located, are the zones for the lowland rain swamp forest and mangrove ecosystems (Ukpong, 2009). On-shore exploration in mangrove swamps accounts for the highest rate of degradation followed by logging activities and communal usage of mangroves (Osuji *et al.*, 2011; Enaruvbe and Atafo, 2016). The aim of this study therefore, is to appraise the changing and effects of inland swamps on the socio-economy of Itu LGA.

2.0 Research Problem

Changes in inland swamps raise environmental concerns on natural resource management, swamp use and their naturally treasured fresh water. Even where Ramsar (2007) listed Niger Delta as the largest system of wetlands in Africa and the third largest globally. Records show that although comprehensive environmental protection laws were introduced in 1988 and new legislation in 2007, ecosystem services of up to US$65 million in value were lost over the Niger Delta (including wetlands in Itu, Akwa Ibom State) between 1984 and 2011 (Ayansina and Ulrike, 2015).

Another problem is inadequate consumer pays laws (penalty measures) for degrading the swamp ecosystem and lack of corporate will in the part of government and local authorities. People prefer paying minimal fines charged when caught than ensuring sustainable development. Consequently, if deliberate efforts are not made to protect the inland swamps in Itu LGA, this viable, delicate and resource ecosystem may soon disappear forever. In view of this, there are observed changes in swamp sizes, services loss, swamp ecosystem and resources depletion, change in community population and occupational changes.

3.0 Study Area

The study area is Itu LGA of Akwa Ibom State, Nigeria. The LGA occupies a landmass of approximately 606.10 square kilometres, and situates between latitudes 5°40$'$ and 5°16$'$ north of the Equator; and longitudes 7°52$'$ and 8°10$'$ east of the Greenwich meridian. The area is part of the Calabar mangrove estuary categorised under the West African mangrove sub formation (Ukpong, 1995). It is bounded on the north by Akamkpa and Odukpani LGAs and east by Calabar South LGA of Cross River State. Similarly, the area is flanked on its western borders by Ibiono Ibom LGA and on the South by Uruan and Uyo LGAs of Akwa Ibom State as shown in Figure 1.

Based on the 1991 population census, Itu LGA is made up of 84 villages with a total population of 256,476 people. For the purpose of this study, 23 communities with dominant inland swamp were selected. The population of people in the 23 sampled communities has significantly increased over the years. With the population of 31,282 in 1991 of the sampled communities the projected population in 2021 is 70,817 persons.

The climate of the area is humid tropical type. Rainfall sometimes occurs throughout the year, and it is largely influenced by the prevailing winds and the area's nearness to the Atlantic Ocean (UN-Habitat, 2006). The temperature is uniformly high with a maximum of 34°C and minimum of 23°C.

The area experiences a high relative humidity that is between 80% and 100% (Ukpong, 1995). The climatic conditions of the area significantly contribute to the sustenance of the swamp environment and the entire ecosystem.

The predominant vegetation type is mangrove which consists of trees and shrubs of few generally varying species including the *Rhizophora* family (*R. racemosa, R. harisonii and R. mangle).* The associated species are *Avicenniaafricana* and *Laguncularieracemosa*. Also, in the region are palms, *Prodococcusbateri, Ancistrophyllumopacum, Nypafrutican*, as well as salt marshes and sea grasses within the coastal region (Ukpong, 1995).

The LGA is rich in water bodies and sea foods. Research shows that the area is rich in solid minerals, crude oil and gas (Isah, 2011). The people are engaged in artisanal fishing and the cultivation of cassava, vegetables, maize and yams in subsistence and commercial quantities. These human activities at the inland swamp involve clearing/cutting down the plants in the mangrove forest and destruction of aquatic fauna, logging and lumbering of wood for cooking and charcoal production for sales. Other activities include sand dredging of the water shores and mining of clay and tapping of other swamp ecosystem resources.

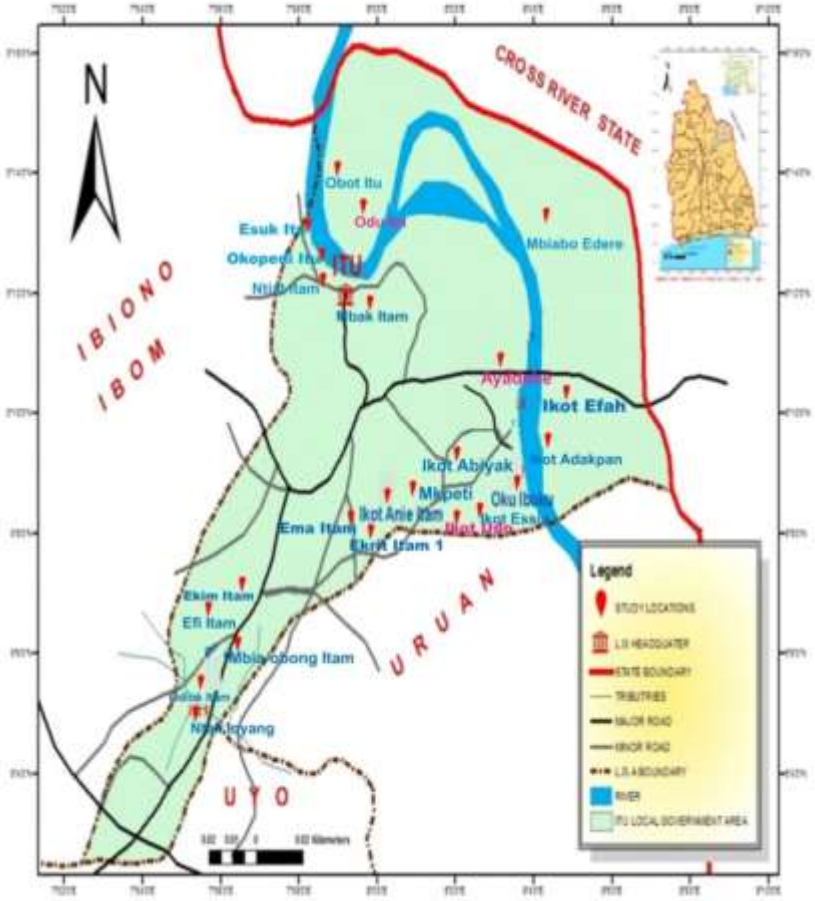


Figure 1: The Study Area on the Map of Itu LGA.
Source: GIS Laboratory, Department of Geography and Natural Resources, UNIUYO (2021)

3.0 Review of Related Literature

As the day passes, the existence of wetlands all over the world are threatened, thus generating a major concern for its sustainable development and management (World Bank, 2009). With recourse to this, the convention on wetlands of international (an inter-governmental treaty) known as the Ramsar Convention or the Convention on Wetlands was proposed and adopted in 1971 to provide a generally

acceptable framework for international co-operation in the area of conservation and wise use or sustainable use of wetlands.

The Ramsar Convention further calls for sustainable wetland development, strong conservation policy guidelines and framework. This includes adoption of maternal wetland polices, reviewing of existing legislation and institutional arrangements to handle wetlands matters. In the same vein, there is need for a strategic structuring of wetland management mechanisms as well as its implementation to ensure the preservation of the physical, chemical and biological characteristics of wetland ecosystems (World Bank, 2009).

Management of wetlands requires more than monitoring but increased interaction and co-operation among the numerous stakeholders. This includes government departments and agencies, the legislature and policy makers, public interest groups, community-based organisations, and research institutions. In line with this, Ekong and Akpan (2014) opined that wetland management and protection should involve regulating inputs through setting water quality standard for wetland and that such inland surface water should sustain their original elements and characteristics while still deriving economic benefits by sustainable ways. To achieve this equally depends on the available data on the state of wetlands within the area of interest.

The wise use of swamps and wetlands is concerned with the ecological character, ecosystem approaches and sustainable development (Ramsar, 2007); while the ecological character is concerned with the ecosystem components, processes and benefits/series that characterize the swamp or wetland at a certain time. The ecosystem approaches deal with complex relationship between elements of an ecosystem as well as promote the integrated management of land, water and living resources (including humans) then the sustainable development is a pattern of resource use to meet human needs with preservation of the environment for use of the present generation and that to come. A typical example of swamp management project in Nigeria is the Iwokiri mangrove conservation project (an Integrated Mangrove Conservation and Research Centre) implemented by the Mangrove Forest Conservation Society of Nigeria (MFCSMN). As a pilot project aims at educating the locals in the rural communities as well as getting them involved in mangrove conservation, it serves as a community-based poverty alleviation project. This project takes over 9 hectares of Iwokiri land in Ogu/Bolo LGA of Rivers State, with estimated cost of N381, 292,358.37 about $3,631,355.00. It is the first and most positive step taken in Nigeria towards improving the mangrove swamp dependent communities (Ekeke, 1999).

Climate change is another factor worth addressing while managing inland swamps and wetlands. The causes of swamp changes have been identified as including road construction, industrialization, settlement expansion, exploitation activities, over exploitation of timber and changes in rainfall pattern and temperature (climate change). As a result of human activities and invasion of the inland swamp environment, as well as improper facility and resource management, there have been a swift decrease and depletion in swamp natural resources and swamp sizes over time. In order to develop the Niger Delta areas, canals and road construction have been extensive since 1980 (Ekeke, 1999). Equally, the activities of the numerous oil exploration companies have led to fragmentation, deforestation and degradation of the mangrove swamp forest ecosystem as their core activities are in the heart of the mangroves. For instance, Shell Petroleum Development Company alone has shot over 120,000km of seismic lines and created vast degraded bare areas (yet to be estimated) resulting from dredging activities in the mangrove forest. Impacts of other petroleum development companies such as ExxonMobil, Total, Elf, Agip, Chevron on the Nigerian mangroves are yet to be estimated. Since slots and canal creation do not consider the impact on local communities and ecosystems a lot of environmental degradation and linked socio-economic problems have been done. Destruction of fishing grounds and swamp die back are just but a few such problems (Ekeke, 1999).

Economic values of a swamp are derived from the values associated with the services it is expected to provide overtime. Swamp services include recreational and educational opportunities, aesthetic, spiritual enrichment, farming/agricultural employment opportunities and other market-based goods and services (King *et al.,* 2000). The inland swamps are basically sources of livelihood for communities and influence/boost the socio-economy of the given area. The swamps provide employment opportunities in the area of agriculture recreation, transportation and mining (sand and gravel) as well as water usage for industrial and domestic purposes. Services identified by Millennium Ecosystem Assessment (2005) are grouped into four main categories as follows: Provisioning (food,

fresh water, fibre and fuel, biochemical, genetic materials); Regulating (climate, hydrological flows, erosion, natural hazard, pollination); Cultural (spiritual and inspirational, recreational, farming, aesthetic, educational); and Supporting (soil formation, nutrient cycling).

Wise use is attributed to Ramsar Convention, a convention that brought to the fore the rising concerns and awareness about the environment. Today, it is fashionable to talk about 'sustainable use' and 'sustainable development' even globally (Matthew, 2010). Although Ramsar Convention did not provide a detailed description of 'wise use' or establish how such 'wise use' was to be implemented, it is clear that parties are to align their activities in such a way that the environment is not unduly degraded (Chase and Knight, 2010).

As the impact of man is contributory to the ever-increasing changes in land use pattern and natural resources, swamp ecosystem use is not exclusive. Sustainable development involves, among other things, elements of good governance and the analysis of trade-offs among uses to enable the effective development and implementation of land-use plans that optimize resource use and minimize conflicts among competing users and thereby conserve resources for future generations (Damen, 2016).

4.0 Research Methodology

The survey design method for data collection was adopted in the study. The LGA was divided into 5 strata representing the different districts that make up Itu LGA and the data collected were analysed using Pearson Product Moment Correlation (PPMC) and descriptive statistical analysis tools. With the aid of questionnaire, primary data were collected from households in the selected communities. The questionnaire design considered demographic/socio-economic variables, swamp ecosystem and land use, management, as well as causes of swamp changes and degradation variables across the region (James, 2008; World Bank, 2009; Adekola and Mitchell, 2011; Irikana, 2011; Onojeghuo and Blackburn, 2011; Ayansina, 2015).

For the purpose of this study, twenty-three (23) communities out 84 from the 5 different districts in Itu LGA were purposively sampled as presented in Table 1.

Table 1: Sampled Villages and Population

S/N	Districts	Name	Population 1996	2019 Projected Population	No of Household	Sample Size
1	West Itam	Odiok Itam	1433	3161	527	18
2		Ntak Inyang	355	783	131	5
3		Efi Itam	1133	2500	417	15
4		Mbiabong Itam	3641	8033	1339	47
5	East Itam	Mbak Itam 1	3086	6808	1135	39
6		Ekim Itam	881	1944	324	11
7		Ema Itam	958	2114	353	12
8		Ikot Annie Itam	1667	3678	613	21
9		Ntiat Itam	875	1930	322	11
10		Mkpeti Itam	457	1008	168	6
11		Ekit Itam 1	3145	6938	1157	40
12	Oku	IkaokuIboku,	1042	2299	383	13
13		Ikot Abiyak,	3603	7948	1325	46
14		Ikot Adakpan,	1066	2352	392	14
15		Ikot Essia	2311	5098	850	30
16	AyadeheandMbiabo	Ikot Efah	971	2142	357	12
17		IkotAkpabio Ayadehe	708	1562	261	9
18		Ikot Udo	580	1279	213	7
19		Mbiabo Edere	806	1778	296	10
20	Itu	Okopedi Itu	815	1798	300	10
21		Obot Itu	815	1798	300	10
22		Esuk Itu	377	832	139	5
23		Odu Itu	557	1229	205	7
		Total	**31,282**	**70,817**	**11,507**	**398**

Source: Researchers' compilation (2021)

The population of the 23 communities according to the Nigerian Population Commission (NPC) 1996 census record was 31,282. With a population growth rate of 3.5, the projected population to 2021 is approximately 70,817 people. Table 2 shows the communities sampled from the five districts of the study area.

Table 2: Sampled Settlements for the Study

S/N	Districts	Communities
1	West Itam District	Odiok Itam, Ntak Inyang, Efi Itam, Mbiabong Itam
2	East Itam District	Ekit Itam 1, Mbak Itam 1, Ekim Itam, Ema Itam, Ikot Annie Itam, Mkpeti Itam, Ntiat Itam
3	Oku District	Ikaoku, Ikot Abiyak, Ikot Adakpan, Ikot Essia
4	Ayadehe and Mbiabo District	Ikot Akpabio Ayadehe, EkotEfah, Ikot Udo, Mbiabo Edere
5	Itu District	Obot Itu, Odu Itu, Esuk Itu, Okpodie Itu

Source: Researchers' compilation (2021)

In determining the sample size that is adequate for this study, the Taro Yamane sampling population formula was employed to arrive at 398 (including the swamp explorers and operators within the study area of interest). This given as:

n= N/1 +[1 N (e)^2] ---------- Equation (1)

Where: n= sample Population, N= finite population (total number of Swamp users in the study area), e = the level of significance (0.03%), 1 = Unit (or Constant).

Table 3: Independent Variables

Variables	Definition	Units of Measurement
Road Construction	Sand filling and construction of road as a result of urbanization	Kilometres
Settlement Expansion	Changes in swamp settlement size	Hectares
Dominant Occupational activities	Dominant occupational activities like sand mining that can cause changes in swamp.	Percentage
Source of energy	Persons using fuel wood as energy source. Thus, leading to over exploitation of timber.	Percentage
Industrialization	Landfilling and industrialization	Number
Change in swamp size	Changes in swamp size as a result of change in rainfall pattern, temperature and human activities	KM^2
Rate of transportation by road	Use of roads for transportation	Percentage
Change in population of swamp settlement	Population of swamp areas because they depend on swamp resources for livelihood	Percentage

Table 4: Dependent Variables

Variables	Definition	Unit of Measurement
Rate of transportation by water ways	Use of inland waterways for transportation	Percentage
Occupational change	Persons that have changed from farming and fishing to service activities	Number
Educational establishment	This includes Primary Schools, Secondary Schools and tertiary institutions.	Number

Educational attainment	Level of education	Number
Access to safe water supply	Sources of water	Type

The relationship between the changes in swamp environment and socio economy of the people were determined. To test the Hypothesis, PPMC in the Statistical Package for Social Science (SPSS) software version 16 was employed.

5.0 Data Presentation, Analysis and Discussion of Results

5.1. The Changes in the Swamp over Time

To determine changes in swamp over time Landsat imageries of 1989, 1999, 2009 and 2019 were employed for analyses. Figures 3 and 4 are the imageries of 1989 and 2019 and Tables 5 presents the base year (1989) data for the various land use covers gathered from Figure 3.

Table 5: Results of land Use/Cover Classification Statistics for 1989

Land use	**1989**	
	km^2	**%**
Water Body	16.991	6.25
Swamp Area	**114.765**	**42.22**
Fallowed Land	83.477	30.71
Cultivated Land	37.567	13.82
Built-up Area	19.041	7.00
Total	**271.841**	**100**

Source: Researchers' computation from Figure 3

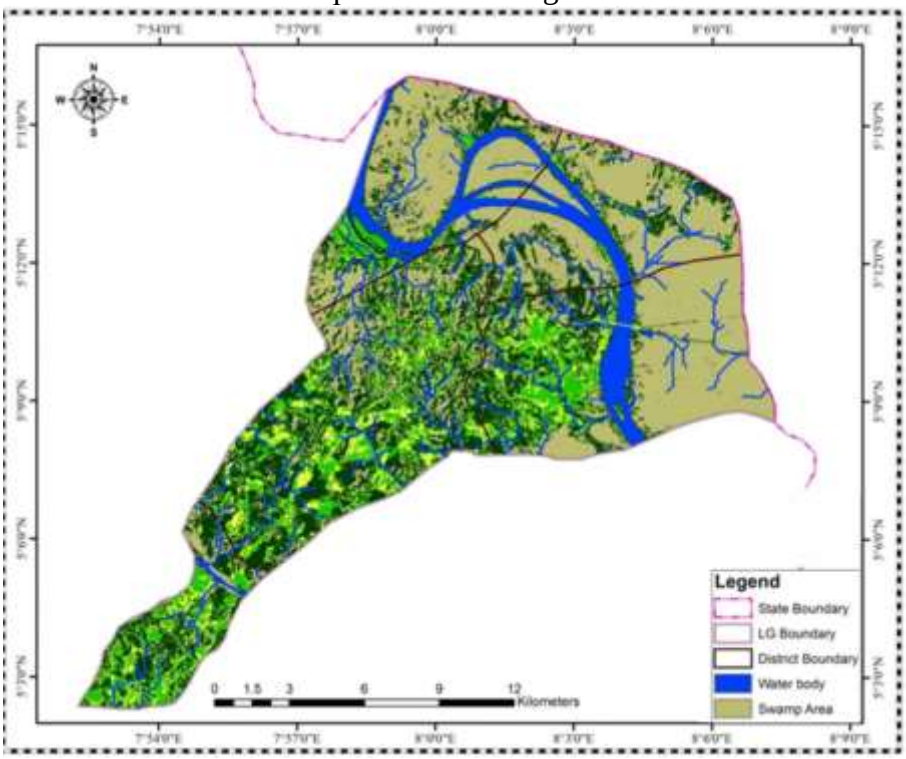


Figure 3: Swamp Area Change Image of the Study Area in 1989
Source: Classified Satellite Image of Itu L.GA. (1989)

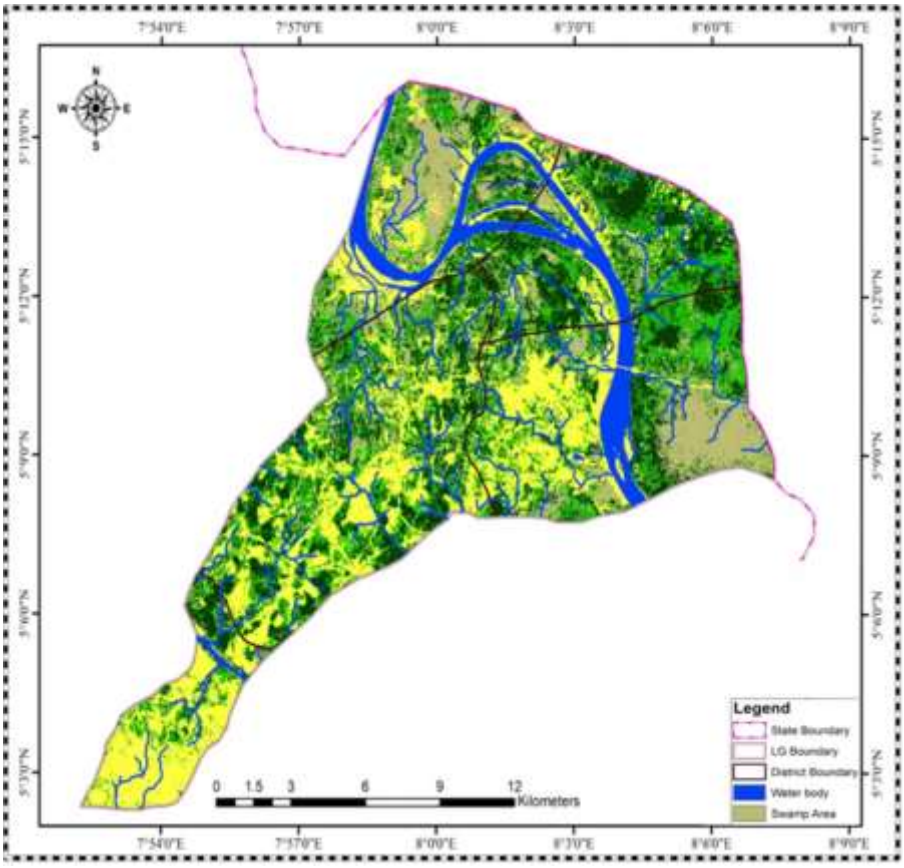


Figure 4: Swamp Area Change Image of the Study Area in 2019
Source: Classified Satellite Image of Itu L.GA. (2019)

Table – 5.43: Results of Swamp Area Change Statistics for 2019

Year	1989	1999	2009	2019
Swamp Area(Km^2)	114.765	107.616	52.807	47.808

Source: Researchers' computation from Figure 4

Land in Itu LGA has been over the years put into different uses, it can be inferred from Figure 6 that the physical development of the area can be seen in phases. Since the scope of this research is on the changes in the inland swamp and how it affects the socio-economy of the study area, the swamp area was analysed and summarized in Table 5 from 1989 to 2019, swamp area in the study area was a total of 114.765km^2 in 1989 while in 2019 it declined to 47.808 km^2. This shows that an average of 2.232 km^2 of swamp area was lost annually in 30 years. Figure 4 shows the trend of the overall swamp changes in the study area from 1989 – 2019.

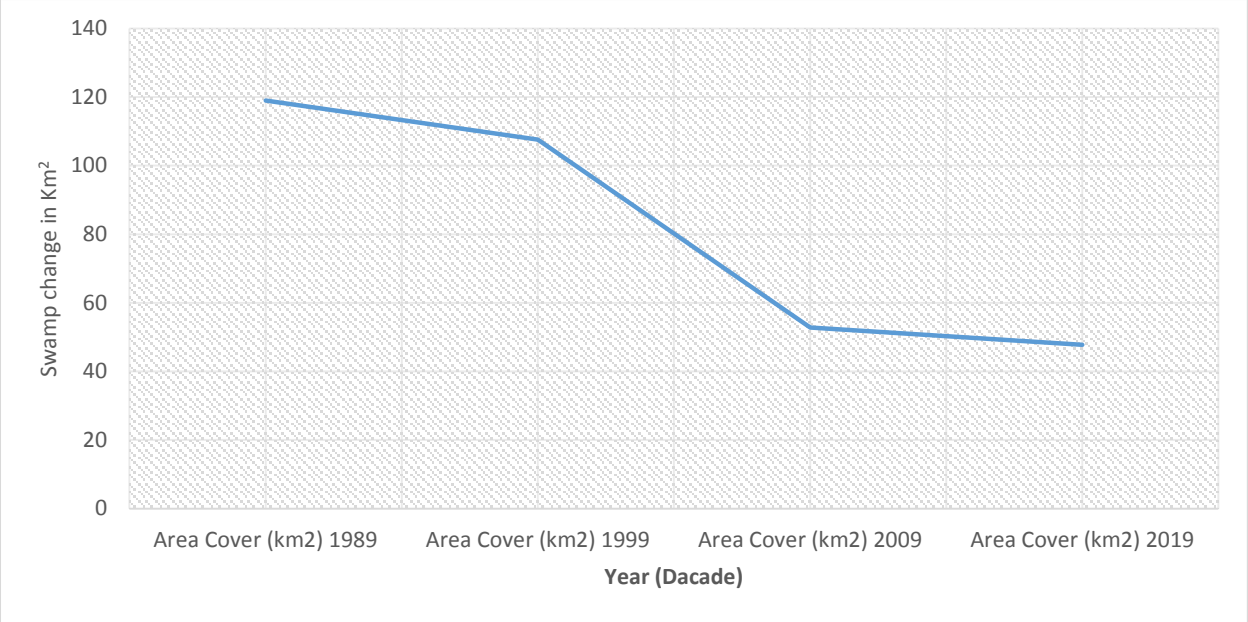


Figure 4: Chart showing summary of swamp cover statistics of Itu
Source: Digitalized data from Satellite Imagery of Itu L.GA. (1989 -2009)

5.2: The Effect of the Change on the Socio-economy of the Study Area over Time

Change in inland swamp over time has greatly impacted the socio-economy of the communities. Hence, the effect of change in inland swamp is as shown in Table 6. To enable correlation, communities were grouped in their districts as follows.

Table 6: Socio-economic data in the study area

S/N	Location	No of Medical Shops	No of Industries, SMEs & Commercial Shops	No of Schools	% of those without secondary Education	% involvement in Farming And Fishing	% of Civil Servants	% of Industrial Workers & Business Persons
1	Mbiabo	5	22	2	27.5	78.3	8.3	13.3
2	Itu	4	38	7	29.63	78.93	5	16.05
3	Oku and Ayadehe	10	121	11	13.40	66.77	12.63	20.45
4	East Itam	21	119	12	16.96	51.91	17.33	31.76
5	West Itam	10	74	7	12.37	16.43	27.07	54.33
	Total	**50**	**374**	**39**	**19.972**	**58.468**	**14.066**	**27.178**

Source: Field Data (2019)

The survey shows that communities in Mbiabo district have a total of 5 functioning medical shops, 22 SMESs and commercial shops, 2 schools, 27.5 percent mean value of persons without secondary education, 78.3 percent mean value for persons involved in farming and fishing, 8.3 percent mean value of civil servants and 13.3 percent mean value of industrial workers and business persons.

Communities sampled in Itu district recorded 4 medical shops and hospitals including Mary Slessor hospital in Obot Itu, 38 SMEs and commercial shops, a total of 7 Schools including primary schools, secondary school and seminary at Obot Itu. The percentage mean of persons without secondary

education is 29.63. Percentage mean of those in farming and fishing is 78.93. The district had 5% of those in civil service and a mean of 16.05 as those that are involved in SMEs.

For Ayadehe and Oku districts, there were only 10 functional medical shops while some were either under construction or dilapidated. This number includes private medical facilities and medical shops. The communities boost of 121 SMEs and commercial shops. Majority were lined-up along the stretch of Iwod Ebop at Ayadehe, the others were around Oku Iboku and Ikot Essia swamps environment. The different communities have a total of 11 schools, while the percentage of persons without secondary school education is 13.40%. The district had 66.77% for persons involved in farming and fishing. Those in civil service amounted to 12.63%, while those in business and SMEs were 20.45%.

For East Itam, the number of medical shops stood at 21, the number of SMEs and commercial shops totalled 119, the number of schools was 12. The percentage of persons without secondary education is 16.96%, farming and fishing recorded 51.91%, those in civil service was 17.33% while industrial works and business account for 31.76%.

For West Itam, the number of medical shops found within the sampled villages was 10 and number of SMEs and commercial shops was 74, while the number of schools was 7. Unlike the other districts, the percentage mean of persons without secondary education within sampled villages in West Itam district stood at 12.37% which is the least in the different districts. Similarly, West Itam recorded the least percentage of 16.43% for persons involved in farming and fishing. West Itam recorded the highest percentage of 27.07% for those in civil service while industrial works and business accounted for 54.33% which is equally the highest among the sampled communities.

High participation of persons in farming and fishing in Mbiabo, Itu, Oku and Ayadehe districts as seen in Table 6 is perhaps due to their proximity to Cross River, with extensive swamps. In East and West Itam communities, changes in swamp environment led to a high degree of occupational change from farming and fishing to other activities. This change is also influenced by the degree of urbanization as some parts of the districts make up Uyo Capital City.

Even with a significant water body like the one in Ntak Inyang and Odiok Itam, depletion in the swamp environment have seriously impacted production of food from the swamp and water bodies. Generally, reduction in the number of persons involved in farming and fishing have a way of impacting the level of food production and supply chain in the study area and the state at large. This in turn could lead to rise in costs of food stuff and leaving.

5.3 Hypothesis Testing

H_{01}: Swamp changes have no significant relationship with the socio-economic development of the area.

Table 7**:** Correlation of swamp changes and the socio-economic development of the area.

		No of Medical Shops	**No of Industries,**	**No of Schools**	**% of those without secondary Education**	**% involvement in Farming and Fishing**	**% of Civil Servants**	**% of Industrial Workers & Business Persons**
Swamp Area Cover (km2) 1989	Pearson Correlation	-.288	-.032	.009	.437	**.917***	**-.857**	**-.935***
	Sig. (2-tailed)	.638	.960	.988	.462	**.028**	**.053**	**.020**
	N	5	5	5	5	5	5	5
Swamp Area Cover (km2) 1999	Pearson Correlation	-.216	.066	.101	.355	**.879***	-.811	**-.899***
	Sig. (2-tailed)	.727	.916	.871	.558	**.050**	.096	**.038**
	N	5	5	5	5	5	5	5
Swamp Area Cover (km2) 2009	Pearson Correlation	-.336	.015	.034	.337	.854	-.796	-.877
	Sig. (2-tailed)	.581	.981	.957	.579	.065	.107	.051
	N	5	5	5	5	5	5	5
Swamp Area Cover (km2) 2019	Pearson Correlation	-.236	.149	.347	.292	.696	-.713	-.677
	Sig. (2-tailed)	.702	.811	.567	.634	.192	.177	.209
	N	5	5	5	5	5	5	5

Source: Field data (2019)

Key:X1= Number of medical shops, **X2** = Number of industries, SMEs and commercial Shops, **X3** = Number of Schools, **X4** = % of those without secondary education, **X5** = % involvement in farming and fishing, **X6** = % of civil servants, **X7** = % of industrial workers and business persons.

The result of the Pearson Correlation analysis shows that there is a significant relationship between changes in swamp environment and the socio-economic variables of the area. Table 7 shows that change in the swamps within the first two decades correlates significantly with occupational activities. Although there is no significant correlation between number of medical shops (X1), number of industries /SMEs and commercial shops (X2), number of schools (X3) and percentage of those without secondary education (X4) there is significant correlation with the percentage of those involved in farming and fishing (X5), percentage of civil servants (X6) and percentage of industrial workers and business persons (X7). This means that the changes in the swamp environment actually impact the occupation of the people. Specifically, area change (km^2) 1989-1999 positively and strongly correlated with percentage involvement in farming and fishing (r = .917; r^2 = 84.08%) and inversely correlated with percentage of civil servants (-.857; r^2 = 73.44%) and percentage of industrial workers and business persons (-.935; r^2 = 87.42%). This implies that as percentage involvement in farming and fishing increases, area change (km^2) 1989– 1999 also increased.

Swamp change in the first decade seriously influenced the types of occupational activities of persons in the swamp environment such that a significant number of persons moved from farming and fishing to civil service with 84.08% and industrial workers and business persons (87.42%). Similarly, swamp changes in the second decade (1999 – 2009) correlates positively with percentage of persons in farming and fishing (.879; r^2 = 77.26%), but inversely correlates with percentage of civil servants, SMEs and business (-.811; r^2) (65.77 %) and industrial workers and business persons (-.899; r^2) (87.42%). This confirms the fact that as swamp area declines (km^2) there is a corresponding increase in the number of those involved in farming and fishing.

5.4 Discussion of Results

The trend of swamp change in the study area shows that within the duration of 30 years, there was a gradual decrease in swamp size. On the impact of changes in swamp environment on the socio-economy of the study area it is revealed that there is a significant relationship between change in swamp' environment and the socio-economic variables of the area. Out of the seven dependent variables of socio-economic activities, only X5, X6 and X6 (occupation of the people) correlate significantly with the changes in the swamp environment.

In line with Duke (2007), Arokoyu and Mom (2010), the swamps are gradually disappearing worldwide at approximately 1 to 2% per year. The decline of the swamp resources is linked to the rapid population growth and expansion of settlements, high poverty, low development indices, poor governance in rural areas and open access of coastal resources, dredging and sand filling for swamp reclamation, urban settlements, road construction, industrial development in swamp areas.

Findings show that with the continuous depletion in the swamp environment, the communities are faced with the challenge of losing their means of livelihood, food from the swamp and water bodies. This finding is in line with King *et al.* (2000) assertion that economic values of a swamp are derived from the values associated with the services it is expected to provide over time.

6.2 Conclusion

The study established a decrease in the change in swamp environment which in turn impacted on the socio-economic lives of people in Itu LGA. Factors like road construction, settlement expansion, exploitation activities, over exploitation of timber, water and soil pollution, change in rainfall pattern and temperature contributed to loss of swamps in the study area.

6.3 Recommendations

To mitigate the current and impending risk that are associated with the changes in inland swamps and the socio-economy of the people of Itu LGA, the following recommendations were made based on the findings of the research:

i. The rate of use and harvest of swamp resources should be done wisely and sustainably. A database for swamp resources harvesting and use should be created for study and monitoring of the trend of swamp changes in the study area.
ii. Environmental Impact Assessment should be conducted before implementing development projects, to avoid negative impacts of road construction, settlement expansion and over exploitation of resources in swamps.

References

Aburto-Oropeza, O. (2008). Mangroves in the Gulf of California Increase Fishery Yields. *Proceedings of Nationa. Academy of Science, U S A.* 105, 10456–9.

Adekola, O. and Mitchell, G. (2011). The Niger Delta Wetlands: Threats to Ecosystem Services, Their Importance to Dependent Communities and Possible Management Measures. *International Journal of Biodiversity Science Ecosystem Service Management*. 7:50–68.

Arokoyu, S. B. and P. C. Mom (2010). Mangrove Forest Depletion, Biodiversity Loss and Traditional Resources Management Practices in the Niger Delta, Nigeria. *Research Journal of Applied Sciences, Engineering and Technology*, ISSN: 2(1), 28-34.

Ayansina, A. and Ulrike, P. (2015). Assessing Wetland Degradation and Loss of Ecosystem Services in the Niger Delta, Nigeria. *Publication on Marine and Freshwater Research,* CSIRO PUBLISHING.http://dx.doi.org/10.1071/MF15066.

Chase, J. M, and Knight, T. M, (2010). "Drought-Induced Mosquitoes Outbreaks in Wetlands", International Water Management Institute.

Damen Shipyard (2016). Sustainable Development Goals. www.damen.com

Duke, N. C.; Meynecke, J. 0.; Dittmann, A. M.; Ellison, A. M.; Aanger, K.; Berger, U.; Cannicci, S.; Diele, K.; Ewel, K.C.; Field, C. D.; Koedam, N.; Lee, S.Y.; Marchand, C.; Nordhaus, I. and Dahdouh-Guebas, F. (2007). A World Without Mangroves! *Science*, 317: 41-42.

Ekeke, B. A. (1999). Reforestation of Bare Degraded Mangrove Areas in the Niger Nwonuala. Delta. Delta Agric. Vol. 6:75-88.

Enaruvbe, G. O. and Atafo, O. P. (2016). Analysis of Deforestation Pattern in the Niger Delta Region of Nigeria. *Journal of Land Use Science.* 11(1):113– 130.

Encyclopaedia Britannica (2021). Swamp Wetland, Encyclopaedia Britannica Inc., 2018.

Ekong, F. U. and Akpan, I. U. (2014). Characteristics and Methods of Wetlands Utilization in Ibiono Ibom LGA., Nigeria. *Journal of Environment and Earth Science.* Vol.4, No.14.

Herr, D.; Pidgeon, E. and Laffoley, D. (2012). Blue Carbon Policy Framework: Based on the Discussion of the International Blue Carbon Policy Working Group. IUCN and Conservation International.

Irikana, G. J. (2011). Mangrove Resources Utilization in Nigeria: An Analysis of the Andoni Mangrove Resources Crisis. *Sacha Journal of Environmental Studies.* 1:49–63.

James, G. K. (2008). Assessment of Environmental Change and its Socio-economic Impacts in the Mangrove Ecological Zone of the Niger Delta, Nigeria: A Ph.D thesis. University of Missouri-Kansas City.

Isah, B. K. (2011). Solid Minerial Resource Development in Sustaining Nigeria's Economic and Environmental Realities of the 21st Century. *Journal of Sustainable Developmentin Africa.* Clarion University of Pensylvania, United State of America. Vol.13, No.2. p 212.

King, M. D. and Mazzotta, M. J. (2000). Ecosystem Valuation‖ Site Funded by US Department of Agriculture Natural Resources Conservation Service and National Oceanographic and Administration.

Matthew, M. (2010). "Wetlands and People". International Water Management Institute.

Millennium Ecosystem Assessment, (2005). *Ecosystems and Human Wellbeing: Wetland and Synthesis*. World Resources Institute. Island Press, Washington, D.CV.

Murray, B. C., Pendleton, L., Jenkins, A. and Silfleet, S. (2011). Green Payments for Blue Carbon Economic Incentives for Protecting Threatened Coastal Habitats. Nicholas Institute Report NI R 11-04. 50 pp.

Nagelkerken, I. (2002). How Important are Mangroves and Seagrass Beds for Coral-reef Fish? The Nursery Hypothesis Tested on an Island Scale. *Mar. Ecol. Prog. Ser.* 244, 299– 305.

National Geographic Society (2018). *National Geography Journal.* National Geographic Headquaters 1145 17th Street NW Washinton, D.C. 20036

National Population Commission (1998, 2004). National Population Policy on Population for Sustainable Development. National Population Comission, Nigeria.

Onojeghuo, A. O. and Blackburn, G. A. (2011). Forest Transition in an Ecologically Important Region: Patterns and Causes for Landscape Dynamics in the Niger Delta. *Ecological Indices*. 11:1437–1446.

Osuji L.C, Erondu E. S., Ogali R.E (2011). Upsteam Petroleum Degradation of Mangroves and Intertidal Shores: The Niger Delta Experience. *Chemistry and Biodiversity.* Vol 7, pp.116 -128.

Ramsar (2007). Handbook for the Wise Use of Wetlands. The Conceptual Framework. Retrieved on September 2, 2021 at www.ramsar.org/key-guide-framework-wiseuse-e.htm. Paper 7.

Salem, M. E. and Mercer, D. E. (2012). The Economic Value of Mangroves: A Meta-Analysis Sustainability 4, 359–383.

Ukpong, I. E. (2009). Perspective on Environmental Management. Environmental Systems Club Uyo pp. 24.

Ukpong, I. E. (1995). Mangrove Soils of the Creek Town, Calabar River Swamp, South Easterm Nigeria, *Journal of International Society for Tropical Ecology* 36 (1): 103-115.

United Nations Environmental Programme (2007). UNEP 2007 Annual Evaluation Report. www.scirp.org

UN-Habitat (2006). State of the World's Cities 2006/7. The Millenium Development Goals and Urban Sustainability: 30 Years Shaping the Habitat Agenda. UN Human Settlements Programme. Earthscan Publications Ltd, London and Sterling. www.scirp.org

Wilkie, M. L and Fortuna, S. (2003). Status and Trends in Mangrove Area Extent World-Wide. Forest Resources Division of the Food and Agricultural Organization of the United Nations. Forest Resources Assessment Working Paper No. 63.

World Bank. (2015). Spatial Disparities and Development Policy. Washington DC: World Bank.

MULTIDECADAL HYDROLOGIC CHANGE AND VARIABILITY IN THE AMAZON RIVER BASIN: ASSESSING THE TWS AND NDVI COMPONENTS IN SOUTH AMERICA

Aniekan Eyoh, John Anwana, Inemesit Ettang, Akwaowo Ekpa
Department of Geoinformatics & Surveying, Faculty of Environmental Studies, University of Uyo, Uyo, Nigeria.
Corresponding Author's Email: aniekaneyoh@uniuyo.edu.ng +2348064733566

Abstract
The study investigated the interannual and interdecadal hydrological changes in the Amazon River basin using GRACE satellite data from 2002-2017 and Moderate Resolution Imaging Spectroradiometer (MODIS)-Aqua dataset. The analyses focused on the dominant mechanisms that modulate terrestrial water storage (TWS) variations. The Study found out that (i) the multi linear regression model simulates the basin-averaged TWS variations remarkably well; however, disagreements were observed in spatial patterns of temporal trends, especially for the post-2008 period. (ii) The 2010s was the driest period since 1980, characterized by a major shift in the decadal mean compared to the 2000s caused by increased drought frequency. (iii) Long-term trends in TWS suggest that the Amazon overall is getting wetter (1.13 mm yr^{-1}), but its southern and southeastern sub-basins are undergoing significant negative TWS changes, caused primarily by intensified LULC changes. (iv) Increasing divergence between dry-season total water deficit and TWS release suggests a strengthening dry season, especially in the southern and southeastern sub-basins. (v) The sub-surface storage regulates the propagation of meteorological droughts into hydrological droughts by strongly modulating TWS release with respect to its storage preceding the drought condition. The study simulations have provided crucial insight into the importance of sub-surface storage in alleviating surface water deficit across Amazon and open pathways for improving prediction and mitigation of extreme droughts under changing climate and increasing hydrologic alterations due to human activities (e.g., LULC change).
Keywords: Hydrologic Change, Amazon River Basin, Terrestrial Water Storage (TWS)

1. **Introduction**

The Amazon River basin is one of the most hydrologically and ecologically diverse regions in the world (Lesack, 1993; Malhi et al., 2008; Lenton *et al.*, 2009; Fan and Miguez-Macho, 2010; Latrubesse *et al.*, 2017; Timpe and Kaplan, 2017; Tófoli *et al.*, 2017 Moran *et al.*, 2018). It is home to the world's largest tropical rainforest and hosts approximately 25 % of all terrestrial species on Earth (Malhi *et al.*, 2008). Hydrologically, it contributes to 20 %–30 % of the world's total river discharge into the oceans (Muller-Karger *et al.*, 1988; Nepstad *et al.*, 2008 Clark *et al*., 2015) and accounts for an estimated 15 % of global terrestrial evapotranspiration (Field *et al.*, 1998; Malhi *et al.*, 2008). Thus, the Amazon is an important

atmospheric moisture transport (Malhi *et al.*, 2008; Soares-Filho *et al.*, 2010).

The hydro-ecological systems of the Amazon are dependent on plentiful rainfall (Nepstad *et al.*, 2008, Espinoza Villar *et al.*, 2009, Cook *et al.*, 2012, Espinoza *et al.*, 2015, 2016) and the vast amount of water that flows down through extensive river networks and massive floodplains (Coe *et al.*, 2002; Bonnet *et al.*, 2008; Frappart *et al.*, 2011; Yamazaki *et al.*, 2011; Miguez-Macho and Fan, 2012; Zulkafli *et al.*, 2016). The spatiotemporal patterns of precipitation are, however, changing due to climate change and variability (Nepstad *et al.*, 2008, Malhi *et al.*, 2008, 2009, Cook *et al.*, 2012, Brando *et al.*, 2014, Lima *et al.*, 2014), large-scale alterations in land use (e.g., deforestation) (Coe *et al.*, 2009; Davidson *et al.*, 2012; Lima *et al.*, 2014; Chen *et al.*, 2015; Panday *et al.*, 2015; Tollefson, 2016; Kalamandeen *et al.*, 2018), and more recently the construction of mega-dams (Soito and Freitas, 2011; Finer and Jenkins, 2012; Latrubesse *et al.*, 2017; Timpe and Kaplan, 2017; Moran *et al.*, 2018), among others. Such changes in precipitation patterns typically manifest themselves in terms of altered magnitude, duration, and timing of streamflow (Marengo, 2005). A prominent streamflow alteration pattern that has been widely observed across the Amazon is the extended dry-season length (Marengo *et al.*, 2011; Espinoza *et al.*, 2016) and an increase in the number of dry events (i.e., droughts) over the longer term (Malhi *et*

al., 2009; Marengo and Espinoza, 2016), which has been suggested to be a result of ongoing climatic and human-induced changes (Shukla *et al.*, 1990; Cook and Vizy, 2008; Malhi *et al.*, 2008; Lee *et al.*, 2011; Cook *et al.*, 2012). However, the cross-scale interactions and feedbacks in the human–water relationship make it difficult to explicitly quantify the causes. These changes have resulted in decreases in runoff (Espinoza *et al.*, 2009; Haddeland *et al.*, 2014; Lima *et al.*, 2014) and loss of terrestrial biodiversity (Barletta *et al.*, 2010; Toomey *et al.*, 2011; Newbold *et al.*, 2016; Tófoli *et al.*, 2017;). Increased variability in streamflow has also resulted in the disruption of the food pulse and fishery yields, which the Amazon region thrives upon (Castello *et al.*, 2013, 2015; Forsberg *et al.*, 2017). Moreover, persistent dry events create negative social externalities, such as deterioration of respiratory health due to drought-induced fires (Smith *et al.*, 2014), exhaustion of family savings (Brondizio and Moran, 2008), and isolation of communities that are affected by river navigation and drinking water scarcity (Sena *et al.*, 2012), hence affecting the overall livelihood of the local communities. Thus, it is critical to understand the characteristics of historical droughts to better understand the dominant mechanisms that modulate droughts and their evolution over time.

As often is the case, droughts in the Amazon are driven by El Niño events; however, some droughts are suggested to be caused by climate change and variability (Marengo *et al.*, 2008; Zeng *et al.*, 2008; Phillips *et al.*, 2009; Espinoza *et al.*, 2011; Lewis *et al.*, 2011; Xu *et al.*, 2011; Marengo and Espinoza, 2016;) and due to accelerating human activities causing rapid changes in the land use and water cycle (Malhi et al., 2008; Lima et al., 2014). Numerous studies have quantified the impacts and spatial extent of these periodic droughts on the hydrological and ecological systems in the Amazon (Fernandes *et al.*, 2011; Lewis *et al.*, 2011; Xu *et al.*, 2011; Davidson *et al.*, 2012; Castello *et al.*, 2013; Satyamurty et al., 2013; Brando *et al.*, 2014; Alho *et al.*, 2015; 2016). For example, Lewis *et al.* (2011) found that the 2010 drought was spatially more extensive than the 2005 drought; the spatial extent was over 3.0 million square kilometers in 2010 and 1.9 million square kilometers in 2005. These catastrophic droughts had major implications on the hydrology of the Amazon River basin; for example, the 2005 hydrological drought led to reduction in streamflow by 32 % from the long-term mean, as reported in Zeng et al. (2008), and in 2010 moisture stress induced persistent declines in vegetation greenness affecting an area of ~2.4 million square kilometers, which was 4 times greater than the area impacted in 2005 (Xu *et al.*, 2011). Moreover, these extreme drought events, coupled with forest fragmentation, have caused widespread fire-induced tree mortality and forest degradation across Amazonian forests (Aragão *et al.*, 2007; Malhi *et al.*, 2008; Rammig *et al.*, 2010; Davidson *et al.*, 2012; Brando *et al.*, 2014).

Due to the limited availability of observed data (e.g., precipitation, streamflow) for the entire basin, hydrologic characteristics of droughts in the Amazon have been studied primarily by using hydrological models and satellite remote sensing. For example, early studies (Lesack, 1993; Vorosmarty *et al*., 1996; Zeng, 1999; Costa and Foley, 1999; Coe et al., 2002;) examined different components of the Amazon water budget and their trends through relatively simpler models. More recent literature (Yamazaki et al., 2011; Fan, 2012a, b; Getirana *et al.*, 2012; Pokhrel et al., 2012a, b,; Paiva et al., 2013a, b; Shin *et al.* 2013; Dias et al., 2015; Miguez-Macho and 2018; Siqueira *et al.*, 2018; Fan *et al*., 2019; Wang et al., 2019;, 2012) provided further advances in modeling the hydrological dynamics connected with anthropogenic activities in the Amazon and other parts of the world. Methods with varying complexities were used in similar studies, ranging from simple water budget analyses (Lesack, 1993; Vorosmarty et al., 1996; Costa and Foley, 1999; Zeng, 1999; Betts *et al.*, 2005; Fernandes *et al.*, 2008; Sahoo *et al.*, 2011;) to state-of-the-art land surface models (Getirana *et al*., 2012; Miguez-Macho and Fan, 2012a, b; Yamazaki *et al.*, 2011, 2012; Paiva *et al.*, 2013a, b; Pokhrel *et al.*, 2013; Wongchuig Correa *et al.*, 2017; Siqueira *et al.*, 2018), with some targeting the overall development of parameterization and process representation in the model (Coe et al., 2008, 2009; Yamazaki et al., 2011; Getirana et al., 2010, 2012, M[illegible] rs f[illegible] 2;

Lima et al., 2014; Wongchuig Correa et al., 2017).

Major drought events in the Amazon, particularly those in recent years, have been detected by satellite remote sensing, and their impacts on terrestrial hydrology have been examined (Chen et al., 2010; Xu et al., 2011; Filizola et al., 2014). In particular, the hydrologic impact of droughts has been revealed by examining the anomalies in terrestrial water storage (TWS) inferred from the Gravity Recovery and Climate Experiment (GRACE) satellites. A significant decrease in TWS over Central Amazon in the

summer of 2005, relative to the average of the five other summer months during the 2003–2007 period, was reported by Chen et al. (2009). However, due to the vast latitudinal extent of the Amazon basin, these severe dry conditions were observed only in some regions of the basin. Xavier et al. (2010) and Frappart et al. (2013) used GRACE TWS estimates to identify the signature of these drought events and suggested that the 2005 drought only affected the western and central parts of the basin, whereas very wet conditions peaking in mid-2006 were observed in the eastern, northern, and southern regions of the basin. Although the ramifications of these extreme droughts have been widely studied using remote sensing datasets (e.g., GRACE), the understanding of their time evolution is limited due to data gaps and short study periods, hence hindering their comprehensive categorization. Further, GRACE provides the changes in vertically integrated TWS variations; thus, variations in the individual TWS components cannot be estimated solely by GRACE. This shortcoming is overcome by using hydrological models that separate TWS into its individual components and provide simulations for an extended timescale. However, discrepancy between models and GRACE observations has also become a major topic of discussion, as most of the global models show an opposite trend in TWS compared to GRACE in the Amazon and other global river basins (Scanlon et al., 2018); yet, no clear explanation or quantification exists in the published literature, apart from the attribution of the discrepancy to model shortcomings.

As referenced above, the changing hydroclimatology of the Amazon basin, along with specific drought-related analysis (e.g., 2005, 2010), has been widely reported in a large body of literature published over recent decades. Several studies have used statistical measures to quantify drought severity (Marengo, 2006; Zeng et al., 2008; Marengo et al., 2008, 2011; Gloor et al., 2013; Joetzjer et al., 2013; Espinoza et al., 2016; Wongchuig Correa et al., 2017; Zhao et al., 2017a), concerning common variables, such as streamflow and precipitation, thus limiting the quantification of drought impact on water stores, viz. flood, groundwater, and TWS. Further, even though these studies encompass different aspects of hydrological and climatic changes, most span only a few years to a decade, except for some precipitation-related studies (Marengo et al., 1998; Marengo, 2004). Other studies have used a relatively longer study period (Zeng, 1999; Costa et al., 2003; Espinoza et al., 2016;), but the spatial extent is limited. Thus, a comprehensive understanding of the interdecadal hydrologic change and variability across the entire basin and that of changes in drought characteristics is still lacking. Given the number of droughts that have occurred and their widespread impact in the Amazon, it is imperative to have a better understanding of these past events so as to anticipate future hydrological conditions (Phipps et al., 2013). Many aspects of the droughts are yet to be studied, such as, the interdependence between TWS and meteorological (precipitation-related) and hydrological (streamflow-related) droughts. A complete categorization of the drought events with respect to their causes and impacts and the resulting basin response is still coming up short.

This study investigated the interannual and interdecadal variability in TWS and drought events in the Amazon River basin. The study was driven by the following key science questions: (i) how do interannual and interdecadal changes in drought conditions manifest as long-term variations in TWS at varying spatial and temporal scales in the Amazon River basin? (ii) What are the impacts of TWS variations on dry-season water deficit and release? Is the Amazonian dry season getting stronger or more severe? (iii) What are the dominant factors driving the evolution of TWS and drought conditions at varying spatial and temporal scales? (iv) How does the sub-surface water storage regulate the water deficiency caused by the surface drought conditions? These questions were answered by using hydrological simulations from a continental-scale hydrological model and the TWS data from GRACE satellites; the goal is to provide a comprehensive picture of characteristics and evolution of droughts in the Amazon with respect to their types and spatial impact. Specifically, this study aimed to (i) examine the impacts of drought conditions on TWS and other hydrological variables, (ii) understand the hydrological variability and drought evolution in the Amazon at an annual and decadal scale over the past four decades, (iii) quantify the role of sub-surface water storage in alleviating the surface drought conditions, and (iv) summarize each drought year by providing a comprehensive characterization for the major drought events in the Amazon and its sub-basins.

2. **Study Area**

The Amazon basin is the part of South America drained by the Amazon River and its tributaries (Fig. 1). The Amazon drainage basin covers an area of about 6,300,000 km^2 (2,400,000 sq mi), or about 35.5 percent of the South American continent. It is located in the countries of Bolivia, Brazil, Colombia, Ecuador, French Guiana, Guyana, Peru, Suriname, and Venezuela. Most of the basin is covered by the Amazon rainforest, also known as Amazonia. With a 5.5 million km^2 (2.1 million sq mi) area of dense tropical forest, this is the largest rainforest in the world. The Amazon River begins in the Andes Mountains at the west of the basin with its main tributary the Marañón River and Apurimac River in Peru. The highest point in the watershed of the Amazon is the second biggest peak of Yerupajá at 6,635 metres (21,768 ft). It is largest basin and is located in Peru. With a length of about 6,400 km (4,000 mi) before it drains into the Atlantic Ocean, it is one of the two longest rivers in the world. A team of scientists has claimed that the Amazon is longer than the Nile, but debate about its exact length continues. The Amazon system transports the largest volume of water of any river system, accounting for about 20% of the total water carried to the oceans by rivers. Some of the Amazon rainforests are deforested because of an increase in cattle ranches and soybean fields. The Amazon basin formerly flowed west to the Pacific Ocean until the Andes formed, causing the basin to flow eastward towards the Atlantic Ocean. Politically the basin is divided into the Peruvian Legal Amazonia, Brazilian Legal Amazônia, the Amazon region of Colombia and parts of Bolivia, Ecuador and the Venezuelan state of Amazonas.

Fig 1: Map of the study region. The area in yellow represents the spatial extent of the Amazon River basin.

3. **Data and Methodology**

3.1.1 **GRACE data**

The TWS products from the GRACE satellite mission are used to validate the TWS simulated by LHF for the 2002–2015 period. Equivalent water height from three processing centers, namely (i) the Jet Propulsion Laboratory (JPL), (ii) the Center for Space Research (CSR), and (iii) the German Research Center for Geoscience (GFZ) (http://grace.jpl.nasa.gov/data/ get-data/) (Landerer and Swenson, 2012), is used along with two mascon products from CSR and JPL; mascon products have been suggested to better capture TWS signals in many regions (Scanlon et al., 2016). Basin-averaged data of variation in TWS anomalies are calculated from GRACE by taking an area-weighted arithmetic mean with varying cell area (Eelfelani *et al*., 2017)

3.1.2 **Precipitation data**

Monthly derived TRMMv7 3B43 rainfall parameters from the National Aerospace and Space Administration (NASA) Goddard Space Flight Center (GSFC) merged with the Integrated Multi-satellite Retrievals for Global Precipitation Measurements (IMERG) were used for this study between April, 2002 and December, 2017. This was applied in the examination of the spatial and temporal inconsistency of rainfall over the CRB (Fig. 2). The TRMM 3B43/IMERG was used to establish the monthly rainfall approximations of the spatio-temporal resolutions at 0.25 by 0.25 degrees (Fig. 3).

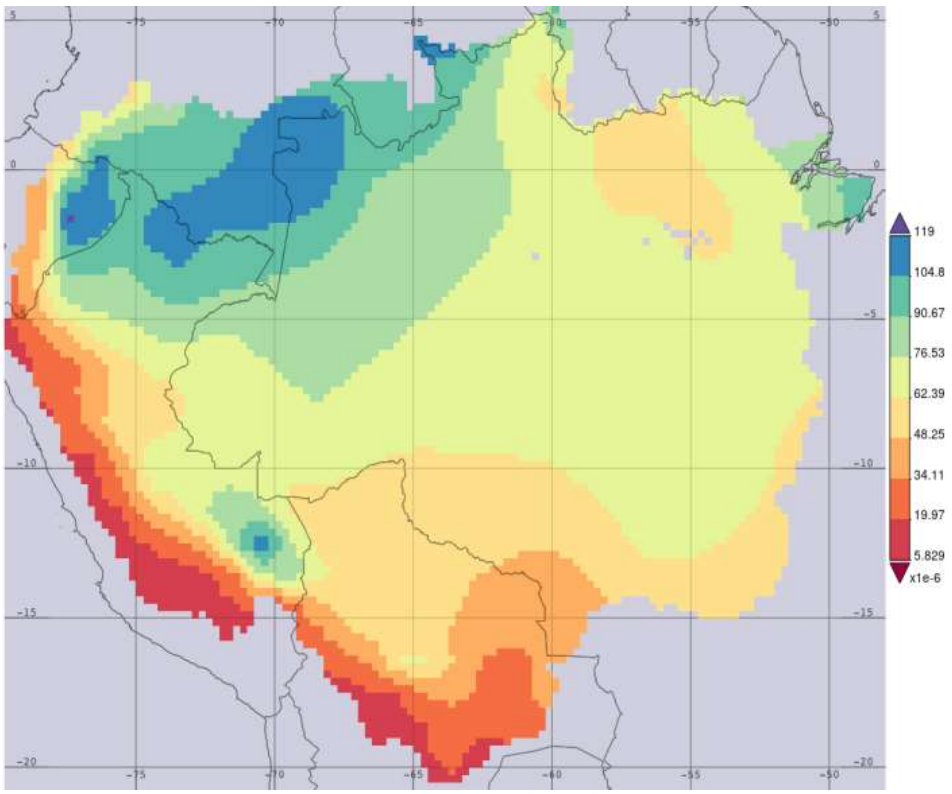


Fig 2. Time averaged map of total precipitation rate over the study region

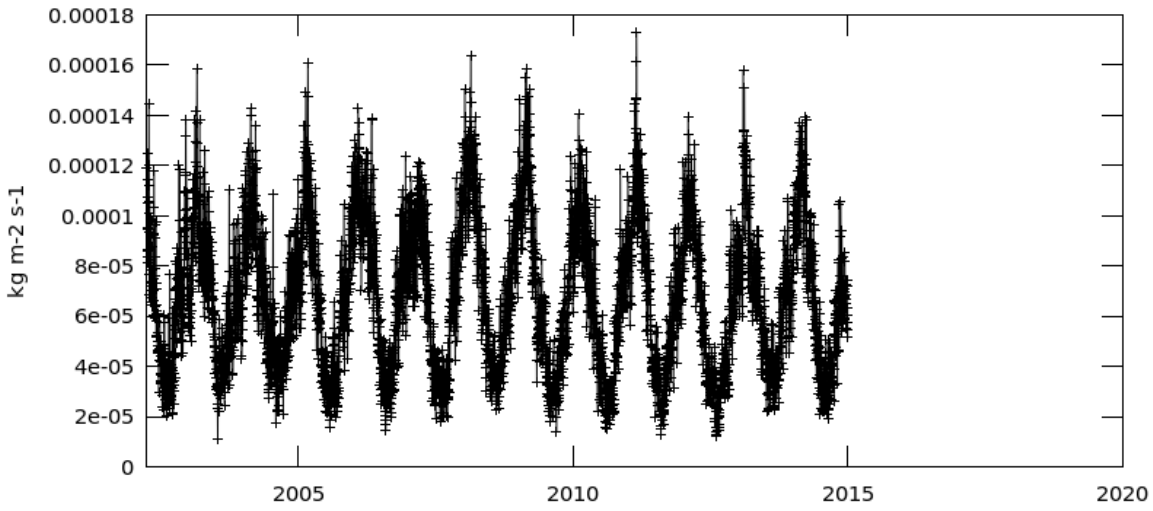


Fig 3. Time series, area-averaged of total precipitation rate daily 0.25 degrees over 2002-2017

A large overestimation in the tropical Amazon rain forest region of South America over the TRMM rainfall radar was determined in December-January-February and in March-April-May and a minimized bias in June-July-August and September-October-November using zonal mean analysis. However, the bias which is largely sharp for all models in the dry seasons when rainfall is nominal is less prominent in the dry seasons of the Amazon River basin. It was necessary to rescale the TRMM/IMERG rainfall dataset in a bid to maintain and preserve a consistent spatial resolution with the other datasets used in this study.

3.1.2 Observed stream flow

We use monthly averaged streamflow data obtained from the Agência Nacional de Águas (ANA) in Brazil (*http://hidroweb.ana.gov.br*). A total of 55 stream gauge stations are selected considering a wide coverage over the Amazonian sub-basins and a good balance between low and high flow values. The major selection criterion is the data length; i.e., we only include gauges with at least 30 years' coverage. In a few cases, such as for the Japura sub-basin, the threshold was overlooked because this criterion resulted in a small number of gauging stations. All the selected stations have observational data for varying time frames with minimal data gaps; the months with missing data are skipped in the statistical analysis.

3.1.3 Vegetation

The vegetation data used in this study are obtained from the MODIS project. The data comprise an annual time series of high-resolution land cover maps for the 1992–2015 period at a 300 m spatial resolution, generated by combining the baseline map from the Medium-spectral Resolution Imaging Spectrometer (MERIS) instrument and the land use–land cover (LULC) changes detected from AVHRR (1992–1999), SPOT-Vegetation (1999–2012), and PROBA-V (2013–2015) instruments. The classification follows the LULC classes defined by the UN Land Cover Classification System (LCCS). Spatiotemporal coverage and resolution of these vegetation maps are consistent with the specific LHF model requirements; hence we use annual land cover input, spatially aggregated to 2 km LHF model grids, following the general practice in hydrologic impact studies (Panday et al., 2015; Arantes et al., 2016;).

Fig 4. Time averaged map of NDVI monthly 0.05 degrees using MODIS-Aqua over 2002-2017

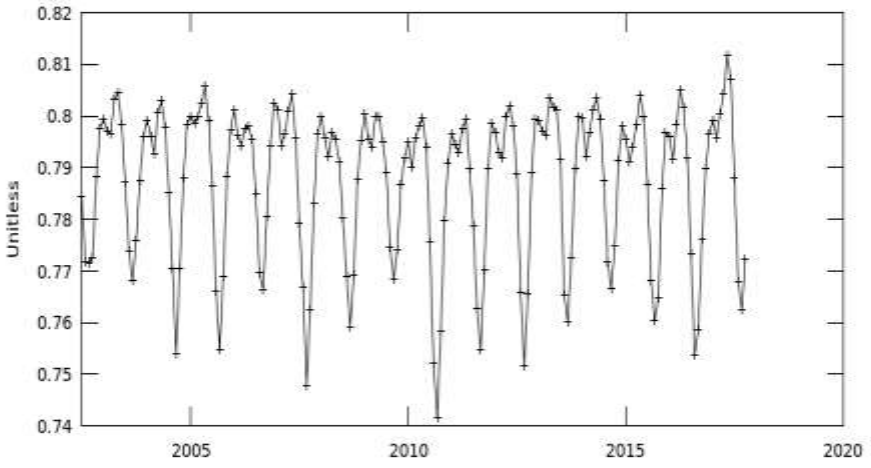


Fig 5: Time series area-averaged of NDVI climate modeling grid monthly 0.05 degrees for MODIS-Aqua over 2002-2017

3.2 Methodology

3.2.1 Multiple Linear Regression Analysis (MLRA)

This variant of regression analysis attempts to evaluate the relationship between dependent (e.g., TWS variations) and independent variables (e.g. precipitation patterns) to model the trends of GRACE-derived TWS and rainfall time series. The MLRA is a robust statistical algorithm which employs the well-known least squares approach in modeling climatic and hydrological datasets. The inter-annual and seasonal variability of the TWS, rainfall and vegetation datasets were however assessed for every grid point using,

$$\widetilde{D}_{T/R} = \gamma_0 + \gamma_{1t_*} + \gamma_2 \sin(2\pi t_*) + \gamma_3 \cos(2\pi t_*) + \gamma_4 \sin(4\pi t_*) + z \quad (3)$$

is correlated to the temporal patterns of the data. Where, $\widetilde{D}_{T/R}$ is a time function (t_*) of the dependent dataset.

, γ_0 and $\gamma_1$describes the constant offset and linear trends respectively, γ_2 and γ_3 represents the annual signals, while γ_4 and γ_5 describes the semi-annual signals, the eccentricity between the derived observations and model outputs is represented by z. The Root Mean Square Error (RMSE), annual and semi-annual amplitudes are given by,

$$RMSE = \sqrt{\frac{1}{mts}\sum_{i=1}\left(obs\left(\widetilde{D}_{\frac{T}{R}}\right) - sim\left(\widetilde{D}_{\frac{T}{R}}\right)\right)^2} \; ; AA = \sqrt{(\gamma_2)^2 + (\gamma_3)^2}; SAA = \sqrt{(\gamma_4)^2 + (\gamma_5)^2} \quad (4)$$

Where $obs\left(\widetilde{D}_{\frac{T}{R}}\right)$ and $sim\left(\widetilde{D}_{\frac{T}{R}}\right)$ represent derived observations and model outputs from eqn. 3 respectively for the monthly interval *mts*. In order to authenticate the strength of the derived model, the correlation, phase lag, RMSE, bias and so on were computed. The acceptability of the MLR model however, is determined by the strength of these validation parameters.

4. Results and Discussion

4.1 Evaluation of simulated TWS anomalies with GRACE

Figure 6 presents the comparison of simulated TWS anomalies and GRACE data for the entire Amazon basin, the individual TWS components are also provided. The multi linear regression model performs very well in simulating the basin-averaged TWS anomalies for the entire Amazon basin and most sub-basins. However, some differences between the simulated and GRACE-based TWS anomaly are

evident, especially in sub-basins with a relatively smaller area and elongated shape (e.g., Purus and Japura). Note that the accuracy of GRACE–model agreement is generally low in such small basins due to high bias and leakage correction errors (Chaudhari *et al.*, 2018; Felfelani *et al.,* 2017; Longuevergne *et al.,* 2010), reflected by higher root mean square error (RMSE) values. Simulated TWS evidently follows precipitation anomalies (shown in blue bars in Fig. 7), implying that any uncertainties in the precipitation forcing could have directly impacted TWS. For example, the simulated TWS peak in 2002 in the Solimoes River basin results from the anomalous high precipitation; however, this could not be validated due to a data gap in GRACE. Overall, the model performance is better in the first half of the simulation period compared to the second half, especially in the western sub-basins including the Solimoes and Japura, which could be partially attributed to the decreasing trend in the precipitation forcing. Figure 7 also shows the seasonal cycle including the contribution of different storage components to TWS. In all the basins, the simulated seasonal cycle matches extremely well with GRACE, adding more confidence to the model results. TWS signal is sturdily modulated by the sub-surface water storage, demonstrating the importance of groundwater in the Amazon, especially in the southwestern sub-basins. The inverse relationship in the seasonal cycle of two sub-surface water stores, viz. precipitation and groundwater, is readily discernable in Fig. 5, which is caused by the competing use of the sub-surface compartment by the two terms (Felfelani *et al.,* 2017; Pokhrel *et al*., 2013). However, in some sub-basins, such as the Purus, Solimoes, and Negro, the low-lying areas with large floodplains cause floodwater storage to be equally prominent.

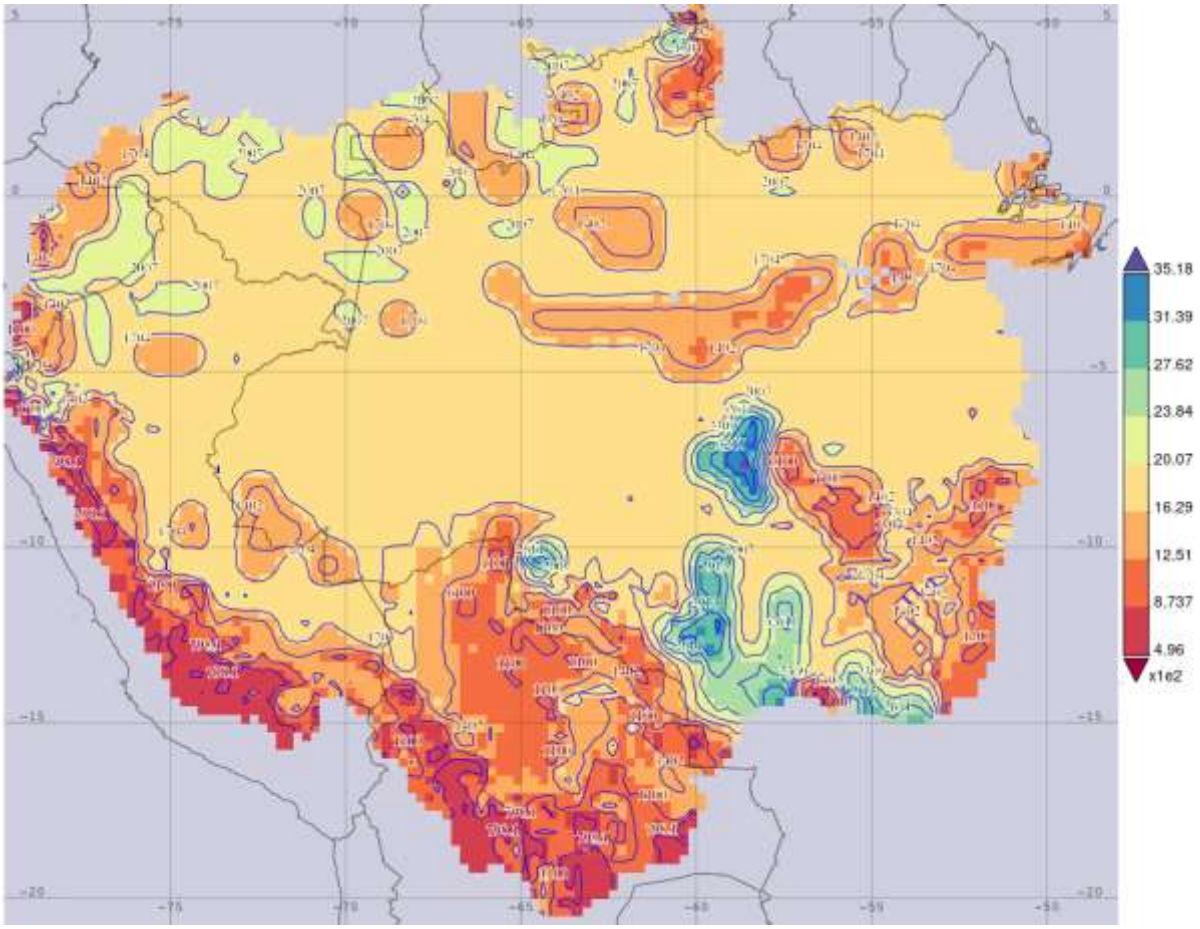


Fig 6 Terrestrial water storage anomalies depiction using contour and shadings

4.2 **Trends in simulated TWS and comparison with GRACE**

Here, we present a more detailed examination of the simulated TWS by comparing its spatial variability and trend with GRACE data. Because a shift in agreement between model and GRACE was detected in Figs. 7 and 8, we conduct a trend analysis for two different time windows: 2002–2008 and 2009–2015. It is evident from Fig. 6 and 8 that the model captures the general spatial pattern of TWS trend in GRACE and its north–south and east–west gradients especially for the first half of the analysis period; however, notable differences are evident in the second half (2009–2015), particularly over the Madeira River basin. This is a noteworthy observation given that the basin-averaged TWS variability matches extremely well with GRACE data (Fig. 6) and thus warrants further investigation. There could be a number of factors contributing to the disagreement, some of which could be model-specific (e.g., wet bias in simulated discharge); however, this is a general pattern observed in many hydrological models as reported in a recent study (Scanlon *et al.*, 2018). Scanlon et al. (2018) indicated a low correlation between GRACE and models, which they attributed to the (i) lack of surface water and groundwater storage components in most of the models, (ii) uncertainty in climate forcing, and (iii) poor representation of human intervention in the models (Scanlon et al., 2018; Sun et al., 2019). Here, we shed more light on the disagreement issue by investigating the contributions from the explicitly simulated surface and sub-surface storage components and their latitudinal patterns, addressing the first concern noted above which is the most critical among the three in the Amazon because of the varying contribution of different stores across scales (Pokhrel *et al.*, 2013). Figure 4 shows trends in NDVI anomalies which is seen to be directly affected by the GRACE products.

Simulated TWS from the multi linear regression model displays a higher correlation with GRACE trends compared to most of the global models discussed in Scanlon et al. (2018). Due to the incorporation of a groundwater scheme and other surface water dynamics, the trend in basin-averaged TWS with climatology removed for the Amazon River basin is found to be $-1.64\,\mathrm{mm\,yr^{-1}}$, much less negative than most of the simulated TWS trends reported in Scanlon et al. (2018). The difference in the sign of trend can partly be explained by the negative trend observed in the precipitation (Fig. 4), concentrated over the Andes region which eventually drains into the main stem of the Amazon through the Solimoes River. Due to steep topography, the impact of decreased precipitation over the Andes range is carried over to its foothills in terms of runoff, hence corresponding well with the negative trends in simulated surface water storage over the Central Amazon (Fig. 6). Lower recharge rates in the region with decreasing precipitation trend are also very likely, which is supported by the negative trend visible in the sub-surface water storage in Fig. 8, over the northwest region of the Amazon. Hence, it can be concluded that, even though the model shows some bias in TWS compared to GRACE data, the model accurately represents the key hydrologic processes in the Amazon basin; yet, these results should be interpreted with some caution while acknowledging the uncertainty in the forcing dataset. We also emphasize that it is important to evaluate models using spatiotemporal trends, especially with GRACE, instead of just using the basin-averaged time series, a commonly used approach in most previous studies.

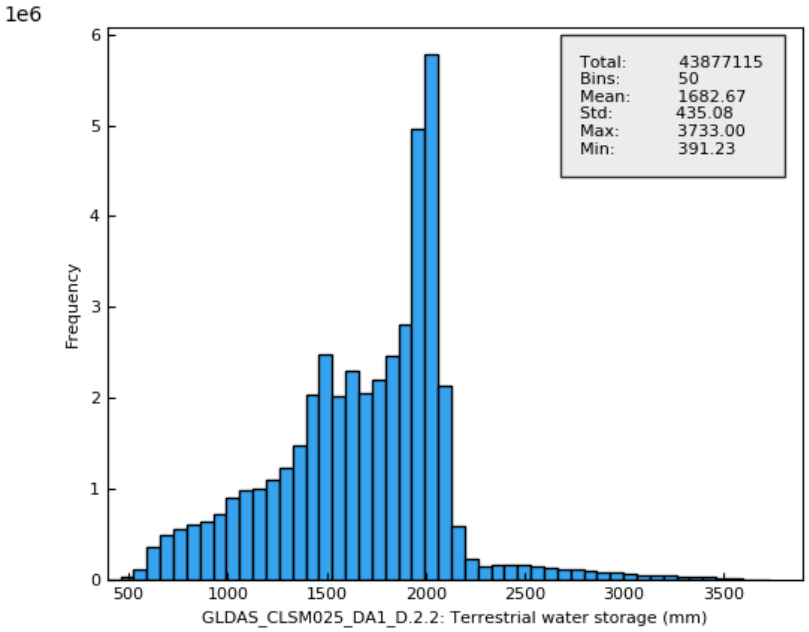


Fig 7. Histogram of daily TWS dataset captured with GRACE over the Amazon from 2002-2017

4.3 Intensification of the Amazonian dry season

Results suggest an increasing trend in TWS with significant decadal variability over the Amazon and its sub-basins, indicating an increase in dry-season length over the past 36 years (Figs. 4, 8). Further, the increasing gap between NDVI and TWS suggests an intensified terrestrial hydrologic system over the dry season during the study period. As the LULC impact is partly accounted for in the PET calculations (i.e., through changing surface albedo), the river basins with substantial LULC change, such as Madeira, Tapajos, Tocantins, and Xingu, portray higher TWDS trend magnitudes (significance > 95 %). The peaks in the TWS correspond well with drought years; for example, the peaks in the TWS for Madeira are analogous to the drought years (e.g., 1988, 1995, 2005, and 2010). Due to this definitive response to drought conditions, TWS is also used to characterize historical drought events in earlier sections. We note that the trends in the total deficit should be interpreted with caution as the uncertainty in the forcing could have affected NDVI (Fig. 2, 3) and TWS (Fig. 6, 8) trend estimates. We find that the river basins that contain high altitudinal areas (Purus, Solimoes, and Negro) have a fairly balanced relationship between NDVI and TWS, but southern and southeastern sub-basins exhibit a higher water deficiency (Fig. 6, 8), with approximately 2- to 3-fold differences between NDVI and TWS during regular years. For drought years, however, the difference between NDVI and TWS is even higher, creating highly anomalous dry conditions in the sub-basins. Consistent higher values of TWS in southern and southeastern sub-basins of the Amazon further highlight the intensification of the dry season, with increasing water deficiency corresponding to an almost constant water supply from NDVI. This phenomenon is also highlighted in Espinoza et al. (2016), which showed an significant increase in dry day frequency in the central and southern parts of the Amazon. Results from this study combined with the reported increasing trend in the wet season (Gloor et al., 2013) imply an overall intensification of the Amazonian hydrological cycle.

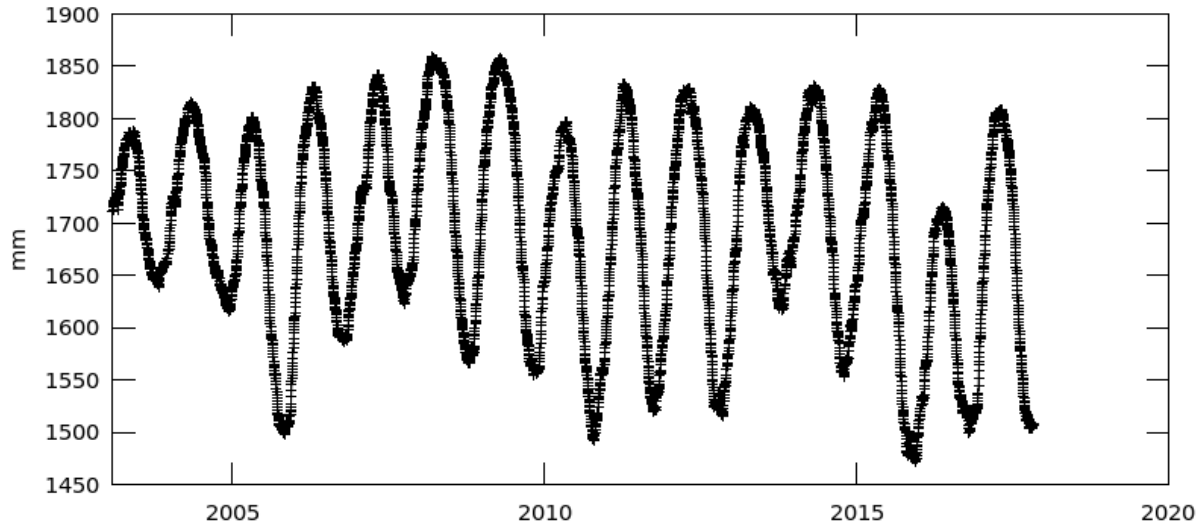


Fig 8. Time series for TWS anomalies over the study region from 2002-2017

Conclusion

This study examined the interannual and interdecadal trends and variability in the terrestrial hydrological system in the Amazon basin using TWS and NDVI products from MODIS and GRACE satellite missions. The has provided an in-depth understanding of the interrelation between different drought types and the corresponding response of the sub-surface storage to surface drought conditions. The key findings are summarized below. First, the multi linear regression model simulates the basin-averaged TWS variations and seasonal cycle remarkably well for most of the sub-basins compared to GRACE data; however, some differences are observed in the spatial distribution of temporal trends for the post-2008 period. The study has found that this discrepancy is caused primarily by the uncertainty in surface water storage simulations along the main stem of the Negro and Amazon, whereas uncertainty in sub-surface storage prevails over the Andes. Second, the 2010–2015 period was found to be the driest in the past four decades due to an increase in the frequency and severity of droughts. A *t* test conducted on the TWS time series also indicated significant changes at the 99 % level in the decadal mean TWS in the Negro and Solimoes sub-basins. Third, high negative long-term trends in TWS and increasing divergence between dry-season total water s (TWS) and corresponding NDVI release indicate significant drying in sub-basins such as Madeira, Tapajos, Xingu, and Tocantins. Basin-averaged trends indicate that the Amazon is getting wetter ($1.13\ mm\ yr^{-1}$); however, its southern and southeastern portions are getting drier. Trends in NDVI is also found to be higher than TWS in these sub-basins, with approximately a 3-fold difference between the two during some drought years, indicating a strengthening dry season in the region. Fourth, most of the extreme meteorological droughts do not propagate to hydrological droughts significantly, as the deficit is absorbed by the sub-surface water storage, further reducing TWS drought severity compared to that of a meteorological drought in the Amazonian sub-basins.

Altogether, these results provide important insights into the interannual and interdecadal hydrological changes and the key mechanisms that govern drought events in the Amazon, along with a novel way of categorizing basin behavior during drought occurrence. This framework can be applied to better predict future hydrological conditions and their corresponding socioeconomic impacts toward taking measures to mitigate the drought impacts and facilitate a relatively facile transition of the local population through a future drought event. Basin drying trends reported in this study can also provide key leverage by applying them toward anticipation of future hydrological conditions for the sustainable management of water resources. The study also highlights the importance of using spatiotemporal trend estimates for model validation, especially with GRACE, instead of the commonly employed approach of time series comparison. Improvement in the correlation between the temporal trends in simulated TWS and the

GRACE anomaly through the inclusion of a prognostic groundwater scheme, which allows dynamic groundwater–surface water interactions in the model framework, is also highlighted. Further, the need to investigate the effects of uncertainties in model forcing to TWS simulations is noted because we find that the trends in precipitation are strongly propagated to TWS simulations.

A limitation of the present study is that the effects of irrigation and man-made reservoirs are not yet incorporated in the framework. The basin-wide effects of the existing dams in the Amazon are small (Pokhrel *et al.,* 2012a); however, as more dams are added across the basin, it will become critical to account for such effects. Model improvement is underway (Pokhrel *et al.*, 2018; Shin *et al.,* 2018), and these issues will be addressed in other studies. Despite some limitations, this study significantly advances the understanding of changing Amazonian hydrology, and the results of the study have important implications for predicting and monitoring extreme droughts in the region; the research framework can also be applied to other global regions undergoing similar hydrological changes.

References

Alho, C. J. R., Reis, R. E., and Aquino, P. P. U.: Amazonian freshwater habitats experiencing environmental and socioeconomic threats affecting subsistence fisheries, Ambio, 44, 412–425, https://doi.org/10.1007/s13280-014-0610-z, 2015.

Aragão, L. E. O. C., Malhi, Y., Roman-Cuesta, R. M., Saatchi, S., Anderson, L. O., and Shimabukuro, Y. E.: Spatial patterns and fire response of recent Amazonian droughts, Geophys. Res. Lett., 34, L07701, https://doi.org/10.1029/2006GL028946, 2007.

Arantes, A. E., Ferreira, L. G., and Coe, M. T.: The seasonal carbon and water balances of the Cerrado environment of Brazil: Past, present, and future influences of land cover and land use, ISPRS J. Photogramm. Remote Sens., 117, 66–78, https://doi.org/10.1016/j.isprsjprs.2016.02.008, 2016.

Asner, G. P., Scurlock, J. M. O., and A. Hicke, J.: Global synthesis of leaf area index observations: implications for ecological and remote sensing studies, Glob. Ecol. Biogeogr., 12, 191–205, https://doi.org/10.1046/j.1466-822X.2003.00026.x, 2003.

Barletta, M., Jaureguizar, A. J., Baigun, C., Fontoura, N. F., Agostinho, A. A., Almeida-Val, V. M. F., Val, A. L., Torres, R. A., Jimenes-Segura, L. F., Giarrizzo, T., Fabré, N. N., Batista, V. S., Lasso, C., Taphorn, D. C., Costa, M. F., Chaves, P. T., Vieira, J. P., and Corrêa, M. F. M.: Fish and aquatic habitat conservation in South America: a continental overview with emphasis on neotropical systems, J. Fish Biol., 76, 2118–2176, https://doi.org/10.1111/j.1095-8649.2010.02684.x, 2010.

Bates, P. D., Horritt, M. S., and Fewtrell, T. J.: A simple inertial formulation of the shallow water equations for efficient two-dimensional flood inundation modelling, J. Hydrol., 387, 33–45, https://doi.org/10.1016/j.jhydrol.2010.03.027, 2010.

Beck, H. E., van Dijk, A. I. J. M., de Roo, A., Dutra, E., Fink, G., Orth, R., and Schellekens, J.: Global evaluation of runoff from 10 state-of-the-art hydrological models, Hydrol. Earth Syst. Sci., 21, 2881–2903, https://doi.org/10.5194/hess-21-2881-2017, 2017.

Betts, A. K., Ball, J. H., Viterbo, P., Dai, A., and Marengo, J.: Hydrometeorology of the Amazon in ERA-40, J. Hydrometeorol., 6, 764–774, https://doi.org/10.1175/JHM441.1, 2005.

Bonnet, M. P., Barroux, G., Martinez, J. M., Seyler, F., Moreira-Turcq, P., Cochonneau, G., Melack, J. M., Boaventura, G., Maurice-Bourgoin, L., León, J. G., Roux, E., Calmant, S., Kosuth, P., Guyot, J. L., and Seyler, P.: Floodplain hydrology in an Amazon floodplain lake (Lago Grande de Curuaí), J. Hydrol., 349, 18–30, https://doi.org/10.1016/j.jhydrol.2007.10.055, 2008.

Brando, P. M., Balch, J. K., Nepstad, D. C., Morton, D. C., Putz, F. E., Coe, M. T., Silverio, D., Macedo, M. N., Davidson, E. A., Nobrega, C. C., Alencar, A., and Soares-Filho, B. S.: Abrupt increases in Amazonian tree mortality due to drought-fire interactions, P. Natl. Acad. Sci. USA, 111, 6347–6352, https://doi.org/10.1073/pnas.1305499111, 2014.

Brondizio, E. S. and Moran, E. F.: Human dimensions of climate change: The vulnerability of small farmers in the Amazon, Philos. T. Roy. Soc. A, 363, 1803–1809, https://doi.org/10.1098/rstb.2007.0025, 2008.

Castello, L., Mcgrath, D. G., Hess, L. L., Coe, M. T., Lefebvre, P. A., Petry, P., Macedo, M. N., Renó, V. F., and Arantes, C. C.: The vulnerability of Amazon freshwater ecosystems, Conserv. Lett., 6, 217–229, https://doi.org/10.1111/conl.12008, 2013.

Castello, L., Isaac, V. J., and Thapa, R.: Flood pulse effects on multispecies fishery yields in the Lower Amazon, R. Soc. Open Sci., 2, 150299, doi:10.1098/rsos.150299, 2015.

Chaudhari, S., Felfelani, F., Shin, S., and Pokhrel, Y.: Climate and Anthropogenic Contributions to the Desiccation of the Second Largest Saline Lake in the Twentieth Century, J. Hydrol., 560, 342–353, https://doi.org/10.1016/j.jhydrol.2018.03.034, 2018.

Chen, G., Powers, R. P., de Carvalho, L. M. T., and Mora, B.: Spatiotemporal patterns of tropical deforestation and forest degradation in response to the operation of the Tucuruí hydroelectric dam in the Amazon basin, Appl. Geogr., 63, 1–8, https://doi.org/10.1016/j.apgeog.2015.06.001, 2015.

Chen, J. L., Wilson, C. R., Tapley, B. D., Yang, Z. L., and Niu, G. Y.: 2005 drought event in the Amazon River basin as measured by GRACE and estimated by climate models, J. Geophys. Res.-Sol. Ea., 114, 1–9, https://doi.org/10.1029/2008JB006056, 2009.

Chen, J. L., Wilson, C. R., and Tapley, B. D.: The 2009 exceptional Amazon flood and interannual terrestrial water storage change observed by GRACE, Water Resour. Res., 46, 1–10, https://doi.org/10.1029/2010WR009383, 2010.

Clark, E. A., Sheffield, J., van Vliet, M. T. H., Nijssen, B., and Lettenmaier, D. P.: Continental Runoff into the Oceans (1950–2008), J. Hydrometeorol., 16, 1502–1520, https://doi.org/10.1175/JHM-D-14-0183.1, 2015.

Coe, M. T., Costa, M. H., Botta, A., and Birkett, C.: Long-term simulations of discharge and floods in the Amazon Basin, J. Geophys. Res.-Atmos., 107, 1–17, https://doi.org/10.1029/2001JD000740, 2002.

Coe, M. T., Costa, M. H., and Howard, E. A.: Simulating the surface waters of the Amazon River basin: impacts of new river geomorphic and flow parameterizations, Hydrol. Process., 22, 2542–2553, https://doi.org/10.1002/hyp.6850, 2008.

Coe, M. T., Costa, M. H., and Soares-Filho, B. S.: The influence of historical and potential future deforestation on the stream flow of the Amazon River – Land surface processes and atmospheric feedbacks, J. Hydrol., 369, 165–174, https://doi.org/10.1016/j.jhydrol.2009.02.043, 2009.

Cook, B., Zeng, N., and Yoon, J. H.: Will Amazonia dry out?, Magnitude and causes of change from IPCC climate model projections, Earth Interact., 16, https://doi.org/10.1175/2011EI398.1, 2012.

Cook, K. H. and Vizy, E. K.: Effects of twenty-first-century climate change on the Amazon rain forest, J. Climate, 21, 542–560, https://doi.org/10.1175/2007JCLI1838.1, 2008.

Costa, M. H. and Foley, J. A.: Trends in the hydrologic cycle of the Amazon Basin, J. Geophys. Res.-Atmos., 104, 14189–14198, https://doi.org/10.1029/1998JD200126, 1999.

Costa, M. H., Botta, A., and Cardille, J. A.: Effects of large-scale changes in land cover on the discharge of the Tocantins River, Southeastern Amazonia, J. Hydrol., 283, 206–217, https://doi.org/10.1016/S0022-1694(03)00267-1, 2003.

Cox, P. M., Betts, R. A., Collins, M., Harris, P. P., Huntingford, C., and Jones, C. D.: Amazonian forest dieback under climate-carbon cycle projections for the 21st century, Theor. Appl. Climatol., 78, 137–156, https://doi.org/10.1007/s00704-004-0049-4, 2004.

Davidson, E. A., de Araújo, A. C., Artaxo, P., Balch, J. K., Brown, I. F., C. Bustamante, M. M., Coe, M. T., DeFries, R. S., Keller, M., Longo, M., Munger, J. W., Schroeder, W., Soares-Filho, B. S., Souza,

C. M., and Wofsy, S. C.: The Amazon basin in transition, Nature, 481, 321–328, https://doi.org/10.1038/nature10717, 2012.

Dias, L. C. P., Macedo, M. N., Costa, M. H., Coe, M. T., and Neill, C.: Effects of land cover change on evapotranspiration and streamflow of small catchments in the Upper Xingu River Basin, Central Brazil, J. Hydrol. Reg. Stud., 4, 108–122, https://doi.org/10.1016/j.ejrh.2015.05.010, 2015.

Dórea, J. G. and Barbosa, A. C.: Anthropogenic impact of mercury accumulation in fish from the Rio Madeira and Rio Negro Rivers (Amazonia), Biol. Trace Elem. Res., 115, 243–254, https://doi.org/10.1007/BF02685999, 2007.

Espinoza, J. C., Guyot, J. L., Ronchail, J., Cochonneau, G., Filizola, N., Fraizy, P., Labat, D., de Oliveira, E., Ordoñez, J. J., and Vauchel, P.: Contrasting regional discharge evolutions in the Amazon basin (1974–2004), J. Hydrol., 375, 297–311, https://doi.org/10.1016/j.jhydrol.2009.03.004, 2009.

Espinoza, J. C., Ronchail, J., Guyot, J. L., Junquas, C., Vauchel, P., Lavado, W., Drapeau, G., and Pombosa, R.: Climate variability and extreme drought in the upper Solimões River (western Amazon Basin): Understanding the exceptional 2010 drought, Geophys. Res. Lett., 38, 1–6, https://doi.org/10.1029/2011GL047862, 2011.

Espinoza, J. C., Chavez, S., Ronchail, J., Junquas, C., Takahashi, K., and Lavado, W.: Rainfall hotspots over the southern tropical Andes: Spatial distribution, rainfall intensity, and relations with large-scale atmospheric circulation, Water Resour. Res., 51, 3459–3475, https://doi.org/10.1002/2014WR016273, 2015.

Espinoza, J. C., Segura, H., Ronchail, J., Drapeau, G., and Gutierrez-Cori, O.: Evolution of wet-day and dry-day frequency in the western Amazon basin: Relationship with atmospheric circulation and impacts on vegetation, Water Resour. Res., 52, 8546–8560, https://doi.org/10.1002/2016WR019305, 2016.

Espinoza Villar, J. C., Ronchail, J., Guyot, J. L., Cochonneau, G., Naziano, F., Lavado, W., De Oliveira, E., Pombosa, R., and Vauchel, P.: Spatio-temporal rainfall variability in the Amazon basin countries (Brazil, Peru, Bolivia, Colombia, and Ecuador), Int. J. Climatol., 29, 1574–1594, https://doi.org/10.1002/joc.1791, 2009.

Fan, Y. and Miguez-Macho, G.: Potential groundwater contribution to Amazon evapotranspiration, Hydrol. Earth Syst. Sci., 14, 2039–2056, https://doi.org/10.5194/hess-14-2039-2010, 2010.
Fan, Y., Li, H., and Miguez-Macho, G.: Global Patterns of Groundwater Table Depth, Science, 339, 940–943, https://doi.org/10.1126/science.1229881, 2013.

Fan, Y., Clark, M., Lawrence, D. M., Swenson, S., Band, L. E., Brantley, S. L., Brooks, P. D., Dietrich, W. E., Flores, A., Grant, G., Kirchner, J. W., Mackay, D. S., McDonnell, J. J., Milly, P. C. D., Sullivan, P. L., Tague, C., Ajami, H., Chaney, N., Hartmann, A., Hazenberg, P., McNamara, J., Pelletier, J., Perket, J., Rouholahnejad-Freund, E., Wagener, T., Zeng, X., Beighley, E., Buzan, J., Huang, M., Livneh, B., Mohanty, B. P., Nijssen, B., Safeeq, M., Shen, C., van Verseveld, W., Volk, J., and Yamazaki, D.: Hillslope Hydrology in Global Change Research and Earth System Modeling, Water Resour. Res., 55, 1737–1772, https://doi.org/10.1029/2018WR023903, 2019.

Felfelani, F., Wada, Y., Longuevergne, L., and Pokhrel, Y. N.: Natural and human-induced terrestrial water storage change: A global analysis using hydrological models and GRACE, J. Hydrol., 553, 105–118, https://doi.org/10.1016/j.jhydrol.2017.07.048, 2017.

Fernandes, K., Fu, R., and Betts, A. K.: How well does the ERA40 surface water budget compare to

1–5, https://doi.org/10.1029/2007JD009228, 2008.

Fernandes, K., Baethgen, W., Bernardes, S., Defries, R., Dewitt, D. G., Goddard, L., Lavado, W., Lee, D. E., Padoch, C., Pinedo-Vasquez, M., and Uriarte, M.: North Tropical Atlantic influence on western Amazon fire season variability, Geophys. Res. Lett., 38, 1–5, https://doi.org/10.1029/2011GL047392, 2011.

Field, C. B., Behrenfeld, M. J., Randerson, J. T., and Falkowski, P.: Primary Production of the Biosphere: Integrating Terrestrial and Oceanic Components, Science, 281, 237–240, https://doi.org/10.1126/science.281.5374.237, 1998.

Filizola, N., Latrubesse, E. M., Fraizy, P., Souza, R., Guimarães, V., and Guyot, J. L.: Was the 2009 flood the most hazardous or the largest ever recorded in the Amazon?, Geomorphology, 215, 99–105, https://doi.org/10.1016/j.geomorph.2013.05.028, 2014.

Finer, M. and Jenkins, C. N.: Proliferation of hydroelectric dams in the andean amazon and implications for andes-amazon connectivity, PLoS One, 7, 1–9, https://doi.org/10.1371/journal.pone.0035126, 2012.

Forsberg, B. R., Melack, J. M., Dunne, T., Barthem, R. B., Goulding, M., Paiva, R. C. D., Sorribas, M. V., Silva, U. L. and Weisser, S.: The potential impact of new Andean dams on Amazon fluvial ecosystems., PLoS One, 12, 1–35, https://doi.org/10.1371/journal.pone.0182254, 2017.

Frappart, F., Papa, F., Güntner, A., Werth, S., Santos da Silva, J., Tomasella, J., Seyler, F., Prigent, C., Rossow, W. B., Calmant, S., and Bonnet, M. P.: Satellite-based estimates of groundwater storage variations in large drainage basins with extensive floodplains, Remote Sens. Environ., 115, 1588–1594, https://doi.org/10.1016/j.rse.2011.02.003, 2011.

Frappart, F., Ramillien, G., and Ronchail, J.: Changes in terrestrial water storage versus rainfall and discharges in the Amazon basin, Int. J. Climatol., 33, 3029–3046, https://doi.org/10.1002/joc.3647, 2013.

Getirana, A. C. V., Bonnet, M.-P., Rotunno Filho, O. C., Collischonn, W., Guyot, J.-L., Seyler, F., and Mansur, W. J.: Hydrological modelling and water balance of the Negro River basin: evaluation based on in situ and spatial altimetry data, Hydrol. Process., 24, 3219–3236, https://doi.org/10.1002/hyp.7747, 2010.

Getirana, A. C. V., Boone, A., Yamazaki, D., Decharme, B., Papa, F., and Mognard, N.: The Hydrological Modeling and Analysis Platform (HyMAP): Evaluation in the Amazon Basin, J. Hydrometeorol., 13, 1641–1665, https://doi.org/10.1175/JHM-D-12-021.1, 2012.

Gloor, M., Brienen, R. J. W., Galbraith, D., Feldpausch, T. R., Schöngart, J., Guyot, J. L., Espinoza, J. C., Lloyd, J., and Phillips, O. L.: Intensification of the Amazon hydrological cycle over the last two decades, Geophys. Res. Lett., 40, 1729–1733, https://doi.org/10.1002/grl.50377, 2013.

Guan, K., Pan, M., Li, H., Wolf, A., Wu, J., Medvigy, D., Caylor, K. K., Sheffield, J., Wood, E. F., Malhi, Y., Liang, M., Kimball, J. S., Saleska, S. R., Berry, J., Joiner, J., and Lyapustin, A. I.: Photosynthetic seasonality of global tropical forests constrained by hydroclimate, Nat. Geosci., 8, 284–289, https://doi.org/10.1038/ngeo2382, 2015.

Haddeland, I., Heinke, J., Biemans, H., Eisner, S., Flörke, M., Hanasaki, N., Konzmann, M., Ludwig, F., Masaki, Y., Schewe, J., Stacke, T., Tessler, Z. D., Wada, Y., and Wisser, D.: Global water resources affected by human interventions and climate change, P. Natl. Acad. Sci. USA, 111, 3251–3256, https://doi.org/10.1073/pnas.1222475110, 2014.

Hanasaki, N., Yoshikawa, S., Pokhrel, Y., and Kanae, S.: A global hydrological simulation to specify the sources of water used by humans, Hydrol. Earth Syst. Sci., 22, 789–817, https://doi.org/10.5194/hess-22-789-2018, 2018.

Jiménez-Muñoz, J. C., Mattar, C., Barichivich, J., Santamaría-Artigas, A., Takahashi, K., Malhi, Y., Sobrino, J. A., and Schrier, G. Van Der: Record-breaking warming and extreme drought in the Amazon r Multi Decadal Hydrologic Change and Variability in the Amazon River Basin: Assessing the TWS and NDVI … 0, 2015.

Joetzjer, E., Douville, H., Delire, C., Ciais, P., Decharme, B., and Tyteca, S.: Hydrologic benchmarking of meteorological drought indices at interannual to climate change timescales: a case study over the

Amazon and Mississippi river basins, Hydrol. Earth Syst. Sci., 17, 4885–4895, https://doi.org/10.5194/hess-17-4885-2013, 2013.

Kalamandeen, M., Gloor, E., Mitchard, E., Quincey, D., Ziv, G., Spracklen, D., Spracklen, B., Adami, M., Aragão, L. E. O. C., and Galbraith, D.: Pervasive Rise of Small-scale Deforestation in Amazonia, Nature, 8, 1600, https://doi.org/10.1038/s41598-018-19358-2, 2018.

Landerer, F. W. and Swenson, S. C.: Accuracy of scaled GRACE terrestrial water storage estimates, Water Resour. Res., 48, 1–11, https://doi.org/10.1029/2011WR011453, 2012.

Latrubesse, E. M., Arima, E. Y., Dunne, T., Park, E., Baker, V. R., d'Horta, F. M., Wight, C., Wittmann, F., Zuanon, J., Baker, P. A., Ribas, C. C., Norgaard, R. B., Filizola, N., Ansar, A., Flyvbjerg, B., and Stevaux, J. C.: Damming the rivers of the Amazon basin, Nature, 546, 363–369, https://doi.org/10.1038/nature22333, 2017.

Lee, J.-E., Lintner, B. R., Boyce, C. K., and Lawrence, P. J.: Land use change exacerbates tropical South American drought by sea surface temperature variability, Geophys. Res. Lett., 38, L19706, doi:10.1029/2011GL049066, 2011.

Lehner, B. and Grill, G.: Global river hydrography, and network routing: baseline data, and new approaches to study the world's large river systems, Hydrol. Process., 27, 2171–2186, https://doi.org/10.1002/hyp.9740, 2013.

Lenton, T. M., Held, H., Kriegler, E., Hall, J. W., Lucht, W., Rahmstorf, S. and Schellnhuber, H. J.: Tipping elements in the Earth System, P. Natl. Acad. Sci. USA, 106, 20561–20563, https://doi.org/10.1073/pnas.0911106106, 2009.

Lesack, L. F. W.: Water Balance and Hydrologic Characteristics of a Rain Forest Catchment in the Central Amazon Basin, Water Resour. Res., 29, 759–773, 1993.

Lewis, S. L., Brando, P. M., Phillips, O. L., van der Heijden, G. M. F., and Nepstad, D.: The 2010 Amazon Drought, Science, 331, LP-554, https://doi.org/10.1126/science.1200807, 2011.

Liang, S. and Xiao, Z.: Global Land Surface Products: Leaf Area Index Product Data Collection (1985–2010), Beijing Normal University, doi:10.6050/glass863.3004.db, 2012.

Lima, L. S., Coe, M. T., Soares Filho, B. S., Cuadra, S. V., Dias, L. C. P., Costa, M. H., Lima, L. S., and Rodrigues, H. O.: Feedbacks between deforestation, climate, and hydrology in the Southwestern Amazon: Implications for the provision of ecosystem services, Landsc. Ecol., 29, 261–274, https://doi.org/10.1007/s10980-013-9962-1, 2014.

Longuevergne, L., Scanlon, B. R., and Wilson, C. R.: GRACE hydrological estimates for small basins: Evaluating processing approaches on the High Plains aquifer, USA, Water Resour. Res., 46, 1–15, https://doi.org/10.1029/2009WR008564, 2010.

Malhi, Y., Roberts, J. T., Betts, R. A., Killeen, T. J., Li, W., and Nobre, C. a: Climate Change, Deforestation, and the Fate of the Amazon, Science, 319, 169–172, https://doi.org/10.1126/science.1146961, 2008.

Malhi, Y., Aragão, L. E. O. C., Galbraith, D., Huntingford, C., Fisher, R., Zelazowski, P., Sitch, S., McSweeney, C., and Meir, P.: Exploring the likelihood and mechanism of a climate-change-induced dieback of the Amazon rainforest, P. Natl. Acad. Sci. USA, 106, 20610–20615, https://doi.org/10.1073/pnas.0804619106, 2009.

Climatol., 78, 79–96, https://doi.org/10.1007/s00704-004-0045-8, 2004.

Marengo, J. A.: Characteristics and spatio-temporal variability of the Amazon river basin water budget, Clim. Dynam., 24, 11–22, https://doi.org/10.1007/s00382-004-0461-6, 2005.

Marengo, J. A.: On the Hydrological Cycle of the Amazon Basin: A Historical Review and Current State-of-the-art, Rev. Bras. Meteorol., 21, 1–19, 2006.

Marengo, J. A. and Espinoza, J. C.: Extreme seasonal droughts and floods in Amazonia: Causes, trends and impacts, Int. J. Climatol., 36, 1033–1050, https://doi.org/10.1002/joc.4420, 2016.

Marengo, J. A., Tomasella, J., and Uvo, C. R.: Trends in streamflow and rainfall in tropical South America: Amazonia, eastern Brazil, and northwestern Peru, J. Geophys. Res.-Atmos., 103, 1775–1783, https://doi.org/10.1029/97JD02551, 1998.

Marengo, J. A., Nobre, C. A., Tomasella, J., Oyama, M. D., Sampaio de Oliveira, G., de Oliveira, R., Camargo, H., Alves, L. M., and Brown, I. F.: The Drought of Amazonia in 2005, J. Climate, 21, 495–516, https://doi.org/10.1175/2007JCLI1600.1, 2008.

Marengo, J. A., Tomasella, J., Alves, L. M., Soares, W. R., and Rodriguez, D. A.: The drought of 2010 in the context of historical droughts in the Amazon region, Geophys. Res. Lett., 38, 1–5, https://doi.org/10.1029/2011GL047436, 2011.

Mckee, T. B., Doesken, N. J., and Kleist, J.: The relationship of drought frequency and duration to time scales, AMS 8th Conf. Appl. Climatol., (January), 179–184, 1993.

Miguez-Macho, G. and Fan, Y.: The role of groundwater in the Amazon water cycle: 1. Influence on seasonal streamflow, flooding and wetlands, J. Geophys. Res.-Atmos., 117, 1–30, https://doi.org/10.1029/2012JD017539, 2012a.

Miguez-Macho, G., and Fan, Y.: The role of groundwater in the Amazon water cycle: 2. Influence on seasonal soil moisture and evapotranspiration, J. Geophys. Res.-Atmos., 117, https://doi.org/10.1029/2012JD017540, 2012b.

Miguez-Macho, G., Li, H., and Fan, Y.: Simulated water table and soil moisture climatology over North America, B. Am. Meteorol. Soc., 89, 663–672, https://doi.org/10.1175/BAMS-89-5-663, 2008.

Monteiro, J. A. F., Strauch, M., Srinivasan, R., Abbaspour, K., and Gücker, B.: Accuracy of grid precipitation data for Brazil: Application in river discharge modelling of the Tocantins catchment, Hydrol. Process., 30, 1419–1430, https://doi.org/10.1002/hyp.10708, 2016.

Monteith, J. L.: Evaporation and environment. The state and movement of water in living organisms. Symposium of the society of experimental biology, 19, 205–234, 1965.

Moran, E. F., Lopez, M. C., Moore, N., Müller, N., and Hyndman, D. W.: Sustainable hydropower in the 21st century, P. Natl. Acad. Sci. USA, 115, 201809426, https://doi.org/10.1073/pnas.1809426115, 2018.

Muller-Karger, F. E., McClain, C. R., and Richardson, P. L.: The dispersal of the Amazon's water, Nature, 333, 56–59, https://doi.org/10.1038/332141a0, 1988.

Müller Schmied, H., Eisner, S., Franz, D., Wattenbach, M., Portmann, F. T., Flörke, M., and Döll, P.: Sensitivity of simulated global-scale freshwater fluxes and storages to input data, hydrological model structure, human water use and calibration, Hydrol. Earth Syst. Sci., 18, 3511–3538, https://doi.org/10.5194/hess-18-3511-2014, 2014.

Myneni, R. B., Yang, W., Nemani, R. R., Huete, A. R., Dickinson, R. E., Knyazikhin, Y., Didan, K., Fu, R., Negron Juarez, R. I., Saatchi, S. S., Hashimoto, H., Ichii, K., Shabanov, N. V., Tan, B., Ratana, P., Privette, J. L., Morisette, J. T., Vermote, E. F., Roy, D. P., Wolfe, R. E., Friedl, M. A., Running, S. W., Votava, P., El-Saleous, N., Devadiga, S., Su, Y., and Salomonson, V. V.: Large seasonal swings in l

)–4823, https://doi.org/10.1073/pnas.0611338104, 2007.

Nepstad, D. C., Stickler, C. M., Filho, B. S., and Merry, F.: Interactions among Amazon land use, forests and climate: prospects for a near-term forest tipping point, Philos. T. Roy. Soc. B, 363, 1737–1746, https://doi.org/10.1098/rstb.2007.0036, 2008.

Newbold, T., Hudson, L. N., Arnell, A. P., Contu, S., De Palma, A., Ferrier, S., Hill, S. L. L., Hoskins, A. J., Lysenko, I., Phillips, H. R. P., Burton, V. J., Chng, C. W. T., Emerson, S., Gao, D., Pask-Hale, G., Hutton, J., Jung, M., Sanchez-Ortiz, K., Simmons, B. I., Whitmee, S., Zhang, H., Scharlemann, J. P. W., and Purvis, A.: Has land use pushed terrestrial biodiversity beyond the planetary boundary?, A global assessment, Science, 353, LP-291, https://doi.org/10.1126/science.aaf2201, 2016.

Nobre, C. A., Sellers, P. J., and Shukla, J.: Amazonian Deforestation and Regional Climate Change, J. Climate, 4, 957–988, https://doi.org/10.1175/1520-0442(1991)004<0957:ADARCC>2.0.CO;2, 1991.
Paiva, R. C. D., Collischonn, W., Bonnet, M.-P., de Gonçalves, L. G. G., Calmant, S., Getirana, A., and Santos da Silva, J.: Assimilating in situ and radar altimetry data into a large-scale hydrologic-hydrodynamic model for streamflow forecast in the Amazon, Hydrol. Earth Syst. Sci., 17, 2929–2946, https://doi.org/10.5194/hess-17-2929-2013, 2013a.

Paiva, R. C. D., Buarque, D. C., Collischonn, W., Bonnet, M. P., Frappart, F., Calmant, S., and Bulhões Mendes, C. A.: Large-scale hydrologic and hydrodynamic modeling of the Amazon River basin, Water Resour. Res., 49, 1226–1243, https://doi.org/10.1002/wrcr.20067, 2013b.

Panday, P. K., Coe, M. T., Macedo, M. N., Lefebvre, P., and Castanho, A. D. de A.: Deforestation offsets water balance changes due to climate variability in the Xingu River in eastern Amazonia, J. Hydrol., 523, 822–829, https://doi.org/10.1016/j.jhydrol.2015.02.018, 2015.

Phipps, S. J., Mcgregor, H. V., Gergis, J., Gallant, A. J. E., Neukom, R., Stevenson, S., Ackerley, D., Brown, J. R., Fischer, M. J., and Van Ommen, T. D.: Paleoclimate data-model comparison and the role of climate forcings over the past 1500 years, J. Climate, 26, 6915–6936, https://doi.org/10.1175/JCLI-D-12-00108.1, 2013.

Pielke, R. A., Cotton, W. R., Walko, R. L., Tremback, C. J., Lyons, W. A., Grasso, L. D., Nicholls, M. E., Moran, M. D., Wesley, D. A., Lee, T. J., and Copeland, J. H.: A comprehensive meteorological modeling system-RAMS, Meteorol. Atmos. Phys., 49, 69–91, https://doi.org/10.1007/BF01025401, 1992.

Pokhrel, Y., Hanasaki, N., Koirala, S., Cho, J., Yeh, P. J.-F., Kim, H., Kanae, S., and Oki, T.: Incorporating Anthropogenic Water Regulation Modules into a Land Surface Model, J. Hydrometeorol., 13, 255–269, https://doi.org/10.1175/JHM-D-11-013.1, 2012a.

Pokhrel, Y., Hanasaki, N., Yeh, P. J.-F., Yamada, T. J., Kanae, S., and Oki, T.: Model estimates of sea-level change due to anthropogenic impacts on terrestrial water storage, Nat. Geosci, 5, 389–392, https://doi.org/10.1038/ngeo1476, 2012b.

Pokhrel, Y., Shin, S., Lin, Z., Yamazaki, D., and Qi, J.: Potential Disruption of Flood Dynamics in the Lower Mekong River Basin Due to Upstream Flow Regulation, Sci. Rep., 8, 17767, https://doi.org/10.1038/s41598-018-35823-4, 2018.

Pokhrel, Y. N., Fan, Y., Miguez-Macho, G., Yeh, P. J. F., and Han, S. C.: The role of groundwater in the Amazon water cycle: 3. Influence on terrestrial water storage computations and comparison with GRACE, J. Geophys. Res.-Atmos., 118, 3233–3244, https://doi.org/10.1002/jgrd.50335, 2013.

Pokhrel, Y. N., Fan, Y., and Miguez-Macho, G.: Potential hydrologic changes in the Amazon by the

084004, https://doi.org/10.1088/1748-9326/9/8/084004, 2014.

Rammig, A., Jupp, T., Thonicke, K., Tietjen, B., Heinke, J., Lucht, W., Cramer, W., Cox, P., and Jupp, T.: Estimating the risk of Amazonian forest dieback Estimating, New Phytol., 187, 694–706, https://doi.org/10.1111/j.1469-8137.2010.03318.x, 2010.

Sahoo, A. K., Pan, M., Troy, T. J., Vinukollu, R. K., Sheffield, J., and Wood, E. F.: Reconciling the global terrestrial water budget using satellite remote sensing, Remote Sens. Environ., 115, 1850–1865, https://doi.org/10.1016/j.rse.2011.03.009, 2011.

Saleska, S. R., Wu, J., Guan, K., Araujo, A. C., Huete, A., Nobre, A. D., and Restrepo-Coupe, N.: Dry-season greening of Amazon forests, Nature, 531, 4–5, https://doi.org/10.1038/nature16457, 2016.

Satyamurty, P., Da Costa, C. P. W., Manzi, A. O., and Candido, L. A.: A quick look at the 2012 record flood in the Amazon Basin, Geophys. Res. Lett., 40, 1396–1401, https://doi.org/10.1002/grl.50245, 2013.

Scanlon, B. R., Zhang, Z., Save, H., Wiese, D. N., Landerer, F. W., Long, D., Laurent, L., and Chen, J.: Global evaluation of new GRACEmascon products for hydrologic applications, Water Resour. Res., 9412–9429, https://doi.org/10.1002/2016WR019494, 2016.

Scanlon, B. R., Zhang, Z., Save, H., Sun, A. Y., Müller Schmied, H., van Beek, L. P. H., Wiese, D. N., Wada, Y., Long, D., Reedy, R. C., Longuevergne, L., Döll, P., and Bierkens, M. F. P.: Global models underestimate large decadal declining and rising water storage trends relative to GRACE satellite data, P. Natl. Acad. Sci. USA, 115, 1080–1089, https://doi.org/10.1073/pnas.1704665115, 2018.

Sena, J. A., de Deus, L. A. B., Freitas, M. A. V., and Costa, L.: Extreme Events of Droughts and Floods in Amazonia: 2005 and 2009, Water Resour. Manag., 26, 1665–1676, https://doi.org/10.1007/s11269-012-9978-3, 2012.

Shin, S., Pokhrel, Y., and Miguez-Macho, G.: High Resolution Modeling of Reservoir Release and Storage Dynamics at the Continental Scale, Water Resour. Res., 55, 787–810, doi:10.1029/2018WR023025, 2018.

Shukla, J., Nobre, C., and Sellers, P.: Amazon Deforestation and Climate Change, Science, 247, LP-1325, https://doi.org/10.1126/science.247.4948.1322, 1990.

Siqueira, V. A., Paiva, R. C. D., Fleischmann, A. S., Fan, F. M., Ruhoff, A. L., Pontes, P. R. M., Paris, A., Calmant, S., and Collischonn, W.: Toward continental hydrologic–hydrodynamic modeling in South America, Hydrol. Earth Syst. Sci., 22, 4815–4842, https://doi.org/10.5194/hess-22-4815-2018, 2018.

Smith, L. T., Aragão, L. E. O. C., Sabel, C. E., and Nakaya, T.: Drought impacts on children's respiratory health in the Brazilian Amazon, Sci. Rep., 4, 1–8, https://doi.org/10.1038/srep03726, 2014.

Soares-Filho, B., Moutinho, P., Nepstad, D., Anderson, A., Rodrigues, H., Garcia, R., Dietzsch, L., Merry, F., Bowman, M., Hissa, L., Silvestrini, R., and Maretti, C.: Role of Brazilian Amazon protected areas in climate change mitigation, P. Natl. Acad. Sci. USA, 107, 10821–10826, https://doi.org/10.1073/pnas.0913048107, 2010.

Soito, J. L. D. S., and Freitas, M. A. V.: Amazon and the expansion of hydropower in Brazil: Vulnerability, impacts and possibilities for adaptation to global climate change, Renew. Sustain. Energy Rev., 15, 3165–3177, https://doi.org/10.1016/j.rser.2011.04.006, 2011.

Sun, A. Y., Scanlon, B. R., Zhang, Z., Walling, D., Bhanja, S. N., Mukherjee, A., and Zhong, Z.: Combining Physically Based Modeling and Deep Learning for Fusing GRACE Satellite Data: Can We Learn From Mismatch?, Water Resour. Res., 55, 1179–1195, doi:10.1029/2018WR023333, 2019.

Taylor, K. E.: Summarizing multiple aspects of model performance in a single diagram, J. Geophys. Res.-Atmos., 106, 7183–7192, https://doi.org/10.1029/2000JD900719, 2001.

Tófoli, R. M. , Dias, R. M., Zaia Alves, G. H., Hoeinghaus, D. J., Gomes, L. C., Baumgartner, M. T., and Agostinho, A. A.: Gold at what cost?, A negaproject threatens biodiversity in the Amazon, Perspect. Ecol. Conserv., 15, 129–131, https: g/10.1016/j.pecon.2017.06.003, 2017.

Tollefson, J.: Deforestation rates spike in Brazil, Nature, 540, 182–183, https://doi.org/10.1038/nature.2016.21083, 2016.

Toomey, M., Roberts, D. A., Still, C., Goulden, M. L., and McFadden, J. P.: Remotely sensed heat anomalies linked with Amazonian forest biomass declines, Geophys. Res. Lett., 38, L19704, doi:10.1029/2011GL049041.

Towner, J., Cloke, H. L., Zsoter, E., Flamig, Z., Hoch, J. M., Bazo, J., Coughlan de Perez, E., and Stephens, E. M.: Assessing the performance of global hydrological models for capturing peak river flows in the Amazon Basin, Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2019-44, in review, 2019.

Van Loon, A. F. and Laaha, G.: Hydrological drought severity explained by climate and catchment characteristics, J. Hydrol., 526, 3–14, https://doi.org/10.1016/j.jhydrol.2014.10.059, 2015.

Van Loon, A. F., Van Huijgevoort, M. H. J., and Van Lanen, H. A. J.: Evaluation of drought propagation in an ensemble mean of large-scale hydrological models, Hydrol. Earth Syst. Sci., 16, 4057–4078, https://doi.org/10.5194/hess-16-4057-2012, 2012.

Vorosmarty, C. J., Willmott, C. J., Choudhury, B. J., Schloss, A. L., Stearns, T. K., Robeson, S. M., and Dorman, T. J.: Analyzing the discharge regime of a large tropical river through remote sensing, ground-based climatic data, and modeling differences (HVPTD) from the 37-GHz scanning multichannel microwave radiometer model (WBM/WTM), Monthly, Water Resour. Res., 32, 3137–3150, https://doi.org/10.1029/96WR01333, 1996.

Walko, R. L., Band, L. E., Baron, J., Kittel, T. G. F., Lammers, R., Lee, T. J., Ojima, D., Pielke, R. A., Taylor, C., Tague, C., Tremback, C. J., and Vidale, P. L.: Coupled atmosphere, biophysics and hydrology models for environmental modeling, J. Appl. Meteorol., 39, 931–944, https://doi.org/10.1175/1520-0450(2000)039<0931:CABHMF>2.0.CO;2, 2000.

Wanders, N. and Van Lanen, H. A. J.: Future discharge drought across climate regions around the world modelled with a synthetic hydrological modelling approach forced by three general circulation models, Nat. Hazards Earth Syst. Sci., 15, 487–504, https://doi.org/10.5194/nhess-15-487-2015, 2015.

Wanders, N. and Wada, Y.: Human and climate impacts on the 21st century hydrological drought, J. Hydrol., 526, 208–220, https://doi.org/10.1016/j.jhydrol.2014.10.047, 2015.

Wanders, N., Wada, Y., and Van Lanen, H. A. J.: Global hydrological droughts in the 21st century under a changing hydrological regime, Earth Syst. Dynam., 6, 1–15, https://doi.org/10.5194/esd-6-1-2015, 2015.

Wang, K., Shi, H., Chen, J., and Li, T.: An improved operation-based reservoir scheme integrated with Variable Infiltration Capacity model for multiyear and multipurpose reservoirs, J. Hydrol., 571, 365–375, https://doi.org/10.1016/j.jhydrol.2019.02.006, 2019.

Weedon, G. P., Balsamo, G., Bellouin, N., Gomes, S., Best, M. J., and Viterbo, P.: Data methodology applied to ERA-Interim reanalysis data, Water Resour. Res., 50, 7505–7514, https://doi.org/10.1002/2014WR015638, 2014.

Wongchuig Correa, S., Paiva, R. C. D., de Espinoza, J. C., and Collischonn, W.: Multi-decadal 7–884, https://doi.org/10.1016/j.jhydrol.2017.04.013, 2017.

Xavier, L., Becker, M., Cazenave, A., Longuevergne, L., Llovel, W., and Filho, O. C. R.: Interannual variability in water storage over 2003-2008 in the Amazon Basin from GRACE space gravimetry, in situ river level and precipitation data, Remote Sens. Environ., 114, 1629–1637, https://doi.org/10.1016/j.rse.2010.02.0( ).

Xiao, Z., Liang, S., Wang, J., Chen, P., Yin, X., Zhang, L., and Song, J.: Use of general regression neural networks for generating the GLASS leaf area index product from time-series MODIS surface reflectance, IEEE Trans. Geosci. Remote Sens., 52, 209–223, https://doi.org/10.1109/TGRS.2013.2237780, 2014.

Xu, B., Park, T., Yan, K., Chen, C., Zeng, Y., Song, W., Yin, G., Li, J., Liu, Q., Knyazikhin, Y., and Myneni, B. R.: Analysis of Global LAI/FPAR Products from VIIRS and MODIS Sensors for Spatio-Temporal Consistency and Uncertainty from 2012–-2016, For., 9, 73, doi:10.3390/f9020073, 2018.

Xu, L., Samanta, A., Costa, M. H., Ganguly, S., Nemani, R. R., and Myneni, R. B.: Widespread decline in greenness of Amazonian vegetation due to the 2010 drought, Geophys. Res. Lett., 38, 2–5, https://doi.org/10.1029/2011GL046824, 2011.

Yamazaki, D., Kanae, S., Kim, H., and Oki, T.: A physically based description of floodplain inundation dynamics in a global river routing model, Water Resour. Res., 47, 1–21, https://doi.org/10.1029/2010WR009726, 2011.

Yamazaki, D., Baugh, C. A., Bates, P. D., Kanae, S., Alsdorf, D. E., and Oki, T.: Adjustment of a spaceborne DEM for use in floodplain hydrodynamic modeling, J. Hydrol., 436, 81–91, https://doi.org/10.1016/j.jhydrol.2012.02.045, 2012.

Zhao, M., A, G., Velicogna, I., and Kimball, J. S.: A Global Gridded Dataset of GRACE Drought Severity Index for 2002–14: Comparison with PDSI and SPEI and a Case Study of the Australia Millennium Drought, J. Hydrometeorol., 18, 2117–2129, https://doi.org/10.1175/JHM-D-16-0182.1, 2017a.

Zhao, M., Geruo, A., Velicogna, I., and Kimball, J. S.: Satellite observations of regional drought severity in the continental United States using GRACE-based terrestrial water storage changes, J. Climate, 30, 6297–6308, https://doi.org/10.1175/JCLI-D-16-0458.1, 2017b.

Zulkafli, Z., Buytaert, W., Manz, B., Rosas, C. V., Willems, P., Lavado-Casimiro, W., Guyot, J.-L., and Santini, W.: Projected increases in the annual flood pulse of the Western Amazon, Environ. Res. Lett., 11, 14013, doi:10.1088/1748-9326/11/1/014013, 2016.

ASSESSMENT OF CRITICAL SUCCESS FACTORS FOR EFFECTIVE RISK MANAGEMENT IN AN INFLATIONARY ECONOMY

Aminu Muhammad Bashir
Department of Quantity Surveying, Bayero University, Kano, Nigeria.
Corresponding author: ambashir.qs@buk.edu.ng

ABSTRACT
Construction projects are a multi-disciplinary enterprise characterised with unique products, complexities and multiple stakeholders interacting at various stages of the project. This necessitates having an effective risk management strategy coupled with identification of the critical success factors. This will enable projects to be successfully delivered within the prevalent global economic challenges of rising inflation, high rates of interest and foreign exchange. This study aimed to assess critical success factors that must be prioritized by construction organisations in an inflationary economy through a critical review of literature and a questionnaire survey of professionals in the building industry across the North-Western Nigeria. Random sampling technique was used to draw samples for the quantitative data. Mean score and standard deviation were used for data analysis to determine the level of significance of the critical success factors (CSFs). The research validated earlier findings on some of the CSFs at the execution stage of construction projects across the distinct categories of organisational, behavioural, procedural and external factors. The study found that 'project management capacity', 'early involvement of contractors', 'knowledge and experience' and 'top management support' are the most significant CSFs for effective risk management of construction projects in an inflationary economy. This study recommends that construction organisations should adopt a holistic approach to risk management at the enterprise level rather than a single project level approach. This will help in enhancing the imperatives of top management support, risk management culture, project/risk management capacity, knowledge and experience in the delivery of construction projects.

Keywords: *critical success factors, risk management, inflationary economy*

INTRODUCTION

Construction industry has been characterized with multiple, complex and adversarial stakeholders that are continually faced with challenges involving many unknown, unexpected and often unpredictable factors in the course of the project phases (Antoniou et al., 2012; Loosemore et al., 2006). These unknown and unexpected factors give rise to risky situations that require proper management for the project to achieve its set goals and objectives (Adeleke et al., 2015; Zou et al., 2010). The inherently risky nature of construction projects due to their uniqueness, constraints and complexity makes the management of risks imperative and necessary if projects are to be successfully delivered (APMBoK, 2006). This necessity is further compounded by the perception of stakeholders to lend more attention to the threats perspective to protect achievement of targeted outcomes than to windfall opportunities that could enhance attainment of same targeted objectives (Edwards and Bowen, 2007). However, it is believed that having a

the anticipated benefits from applying the risk management process, certain factors must exist.

These factors are considered as the Critical Success Factors (CSFs) that would facilitate the effective application of risk management process in the construction industry. El-Sayegh & Mansour (2015) opined that creating an adequate environment for the risk management process will not only minimize risks but enhance the effectiveness of the process. In today's globalized and interconnected world, organizations face a multitude of risks that can significantly impact their operations, financial stability, and long-term sustainability (Hwang et al., 2014). The dynamic and complex nature of the global economy, coupled with uncertainties arising from geopolitical events, technological advancements, natural disasters, and force majeure such as the Covid-19 pandemic have further heightened the need for effective risk management practices. The global financial crisis of 2008-2009 and the recent COVID-19 pandemic have demonstrated the catastrophic consequences of inadequate risk management practices. Organizations that were ill-prepared or lacked robust risk management frameworks faced severe disruptions, financial losses, reputational damage, and even bankruptcy. Consequently, there is an urgent need to identify critical success factors that can enhance risk management capabilities and enable organizations to navigate economic uncertainty effectively (PwC, 2020). In the face of economic

uncertainty, organizations must proactively identify, assess, and mitigate risks to safeguard their business interests and maintain a competitive advantage (Borodovsky, & Kaushansky 2019). This study aimed to assess effectiveness of the CSFs amidst uncertain economic conditions. The aim was achieved by the following objectives of identifying CSFs for effective risk management from the literature, assessing the level of significance of each of the factors and ultimately highlighting the role of these factors in achieving the promised rewards from a systematic application of the risk management process.

LITERATURE REVIEW

Construction organisations need to develop and implement proper risk management processes for the following reasons. First, to establish duty of care associated with their business pursuits as a legal requirement of the Law (Zou *et al.,* 2010). Secondly, to address the uniqueness of each project with its associated complexity and risk factors (Zavadskas *et al*., 2010; Zhi, 1995). Thirdly, to deal with changes in project participants, environment, construction method and teams of varying skills and backgrounds (Zou *et al*., 2010). Finally, to achieve efficient use of human and material resources through lessons learnt for spread and usage in future projects (Serpell, Ferrada, Rubio, & Arauzo, 2015). The negative consequences of failure to implement risk management processes in construction organisations results in, amongst others, increased uncertainty to projects outcome, financial losses and ineffective decision making (Hoseini *et al*., 2018; Loosemore *et al*., 2006; Zou *et al.,* 2010).

Shayan et al (2022) identified 24 Critical success factors (CSFs) at the execution stage and grouped them under organisational factors, human behavioural factors, procedural factors and external factors. These factors influence the success and promote the achievement of project objectives. The concept of CSFs for construction project is not common in the context of the Nigeria construction industry. CSFs of a project are a concept that has been widely researched in the literature because of its relevance to a business organization. CSFs generally connote areas or aspects that impact positively on the achievement of project objectives. Dalcher (2012) asserted that CSFs of a project consist of events, conditions, and circumstances surrounding the project that could contribute to its successes. They are constraints which the project is exposed to and if appropriately managed, could result in project success. Given the prevalent economic uncertainties characterised by high interest rates, galloping inflation, and erratic foreign exchange rates with multiplier effect on construction costs, effective and efficient project management is crucial to achieving project success in the construction industry (Adeleke *et al*., 2015; FDC, 2023). Among various attributes for successful project management, various studies asserted the importance of CSFs for effective and efficient risk management (Banihashemi *et al*., 2017; Chen *et al.,* 2012; Yong & Mustaffa, 2017). It is imperative to identify CSFs in order to focus on the most overarching risks first rather than focus on all potential risks because a construction project cannot be free from other constraints such as time and budget (Rodrıguez- Segura *et al*., 2016).

Zhao *et al*. (2013) recognized top management support including risk ownership and training support as the CSFs for effective risk management at the enterprise level. Oliveira *et al*. (2018) pointed out that the CSFs need to be understood strategically rather than based on individual projects level. This was further supported by Phu (2017) to enable organisations take decisions at an enterprise risk management level for effective communication and management of risks based on common risk language. The 24 CSFs categorized into organizational factors, human behavioral factors, procedural factors, and external factors are,

Table 1- Critical Success Factors for effective risk management

CSFs category	Labels	CSFs
Organizational factors	CSF1	Top management support
	CSF2	Availability of resources
	CSF5	Project management capacity
	CSF9	Organizational strategy
	CSF17	Organization's risk culture
	CSF18	Organization's technological capacity
Human behavioural factors	CSF3	Timely communication
	CSF4	Knowledge and experience
	CSF8	Collaboration among project parties
	CSF11	Positive human dynamics
	CSF15	Project staffs' participation in risk management
	CSF24	Common risk language
Procedural factors	CSF6	Clear roles and responsibilities
	CSF13	Robust risk management procedures
	CSF14	Document control
	CSF16	Procurement method
	CSF19	Early involvement of contractors
	CSF20	Continuous improvement
External factors	CSF7	Project type
	CSF10	Business environment
	CSF12	Customer's demand
	CSF21	Economic environment
	CSF22	Industry risk management standards
	CSF23	Socio-cultural forces

Source: Shayan *et al*. (2022)

The construction sector deals mainly with the provision of capital infrastructure, which has an impact on economic growth. The delivery of such infrastructure creates significant employment opportunities for the population, which generates further investment in other sectors of the economy through the multiplier effect. The construction industry is frequently used as a tool by government to manage and improve the local economy when the cost of construction works is stable or reasonable. This results in improvement in profit margin and the risk of operations would be at minimal (World Bank Group, 2017). Inflation is seen as a crucial variable for potential economic conditions, where sustainable economic growth is a primary goal of every nation (FDC, 2022; Simoni & Boland, 2019). The shift in inflation rates is a challenge to calculate and track monetary policy analysis on time, and any resulting ambiguity is a sign of the incredibility of policy decisions (Gulsen & Kara, 2019). Whereas reliable inflation rate forecasts are important for monetary policy, various factors should be considered to assess and monitor the impact of inflation levels, such as interest rate, potential output, exchange rate, money supply, wage rate, trade openness and expectations (Ghosh, 2014; Szafranek, 2019).

In Nigeria, inflation is currently at a record high of 22.04%. It averaged 18.8% in 2022, the highest in 21 years. The Russia-Ukraine war led to a spike in global commodity prices. Since Nigeria is a net-importing country, the price shock partly contributed to high inflation in Nigeria (FDC, 2023). Currency depreciation, which is a major contributing factor to inflation, was fueled by capital flight as global monetary authorities raised interest rates to curb inflation. The Monetary Policy Committee in Nigeria responded to the spiraling inflation by raising interest rates cumulatively by 500 basis points (bps) to 16.5% per annum in 2022. It raised it by another 100bps early this year. However, the federal government maintained an expansionary policy, with budget expenditure at an all-time high of N12.87 trillion as of November 2022. Nigeria's budget deficit rose by 83% compared to N4.1 trillion in 2021 (FDC, 2023). The multiplicity of macro-economic indicators of rising inflation, increased interest rates, non-availability of foreign direct investment has stagnated the economy with bleak potentials for growth. This is especially relevant to the construction industry as a major sector of the economy. This study therefore assessed the CSFs for effective risk management in the light of economic uncertainties thereby highlighting the most significant factors for effective risk management that will enhance profitability and efficient utilisation of resources.

METHODOLOGY

This study adopted a quantitative approach of data collection to achieve its objectives. This involved quantitative data collection using 5-point Likert scale questionnaire to determine the level of significance of critical success factors for effective risk management in uncertain economy. Based on

the questionnaire survey.

The population of the study comprised of registered construction professionals involved in the building construction industry in the seven North-western states which stood at 1,655 (MOW&H, 2023). For the

purpose of this research a random sampling technique was used. Random probability sampling is a method of sample selection which gives possible sample an equal probability of being picked up and each item in the entire population to have an equal access of being included in the sample.
Using the formula from Kish (1995) in equations (1) and (2), the sample size was determined as 94. However, in view of the low response of questionnaire survey as opined by Creswell (2012), 100 copies of questionnaires were administered using the house-hold drop off technique which provides opportunity for clarification on any aspect to the respondents. 64 questionnaires were retrieved and sorted with 55 found adequate for further analysis. The Statistical Product for Service Solution (IBM SPSS) version 21 software was used to analyse the quantitative data.

$$N_0 = (p * q)/v^2 \quad (1)$$

$$n = N_0/[1 + (N_0/N)] \quad (2)$$

Where:

$N_0 =$ First estimate of sample size

$p =$ The proportion of the characteristic being measured in the target population;

$p = 0.5$ Considering a confidence level of 95%;

$q =$ Complement of p, $q = (1 - p), 1 - 0.5 = 0.5$

$v =$The maximum standard of error allowed $= 0.05$

N= The population size = 1655

n= The sample size

$N_0 = (0.5 * 0.5)/(0.05)^2$= 100

$n =$ 100/ [1+ (100/1655)] = 94.30

RESULTS

Total of 100 professionals were selected for the questionnaire survey, and the response rate was 55% (55 out of 100). The average experience of respondents was 11 years, and 40% (22 respondents) have more than 20 years of experience in managing projects and risks over a project life cycle. The respondents' profile is as shown in Table 2.

Table 2 - Professional Qualification of Respondents

Qualification	Frequency	Percentage (%)
Architects	10	18.18
Quantity Surveyors	15	27.27
Engineers	12	21.82
Project Managers	18	32.73
Total	55	100

Source: Field survey (2023)

The respondents were asked to rank the significance of CSFs of each category, and the result is presented as shown in Table 3.

Table 3- Ranking of the level of significance of Critical Success Factors

CATEGORY	STATEMENT	N	MIN	MAX	MEAN	STD. DEV.	GROUP RII	GROUP RANK	OVERALL RANK
ORGANISATIONAL FACTORS	Project Management Capacity	55	4	5	4.82	0.39	0.96	1	1
	Organization's risk culture	55	4	5	4.33	0.47	0.87	2	4
	Top Management Support	55	3	5	3.87	0.8	0.77	3	13
	Organizational Strategy	55	2	5	2.96	0.72	0.59	5	22
	Organizational Technological Capacity	55	1	4	2.62	0.85	0.52	6	24
	Availability of Resources	55	1	5	3.00	1.48	0.60	4	21
HUMAN BEHAVIOURAL FACTORS	Knowledge and experience	55	2	5	4.56	0.96	0.91	1	3
	Common risk language	55	2	5	4.09	1.11	0.82	4	9
	Project staffs' participation in risk management	55	2	5	4.31	0.84	0.86	2	5
	Collaboration among project parties	55	2	5	4.11	1.03	0.82	3	8
	Timely communication	55	2	5	3.62	0.93	0.72	5	16
	Knowledge and experience	55	2	5	3.56	0.79	0.71	6	18
PROCEDURAL FACTORS	Early involvement of contractors	55	3	5	4.58	0.53	0.92	1	2
	Continuous improvement	55	1	5	3.89	1.1	0.78	3	12
	Document control	55	3	5	4.13	0.67	0.83	2	7
	Clear roles and responsibilities	55	1	5	3.33	1.17	0.67	5	20
	Robust risk management procedures	55	1	5	2.82	1.22	0.56	6	23
	Procurement method	55	2	5	3.51	0.72	0.70	4	19
EXTERNAL FACTORS	Socio-cultural forces	55	1	5	4.20	1.04	0.84	1	6
	Industry risk management standards	55	2	5	4.05	0.93	0.81	3	11
	Economic environment	55	3	5	4.09	0.8	0.82	2	9
	Customer's demand	55	2	5	3.80	0.91	0.76	4	14
	Business environment	55	2	5	3.71	1.03	0.74	5	15
	Project type	55	2	5	3.62	0.97	0.72	6	16

Source: Field survey (2023)

DISCUSSIONS

Within the category of organizational factors, project management capacity is selected as the first most significant CSF with a relative importance index (RII) of 0.96. Respondents signified that an organization must be matured enough to master project management practice prior to engaging risk management. This is supported by the organization's risk culture' (RII = 0.87) as the second most significant CSF which can only be developed once an organization has a certain level of project risk management maturity. Closely preceding the top two CSFs under this category is 'Top Management Support' with an RII value of 0.77. A cursory look at the top three CSFs elucidate a nexus between project management capacity, organisation's risk culture and top management support. These findings are in tandem with previous studies even though some of the CSFs were evaluated at the construction stage of the project (Banihashemi *et al*., 2017; Shayan *et al*., 2022; Zhao *et al*. 2014). The least significant CSF within this category is organisational technological capacity with an RII value of 0.52. This could understandably be in view of more significance attached to the other CSFs.

For the human behavioral factors category, respondents indicated that 'Knowledge and Experience' is the most significant CSF with an RII value of 0.91. This underscores the importance of knowledge and experience in the practice of effective risk management to cope with changes and risks that could eventuate at any moment. Furthermore, respondents emphasized that an experienced and knowledgeable risk champion or a manager must lead the risk management practice in order not to cause confusions and unclear roles and responsibility issues among project team members. Thus, ranking projects staff participation in risk management as the second most significant CSF with an RII value of 0.86. These results further supported Zhao *et al.* (2014) which suggested the appointment of a dedicated senior level executive to deal with risk management at the enterprise level.

For the procedural factors category, respondents commonly pointed out the fragmented nature of a construction project, and it is the main reason why the 'early involvement of contractors' is chosen as the most significant CSF (RII = 0.92) for effective risk management. This will ensure that economic risks are mitigated and transferred to the Contractor at an early stage of the project. In addition, respondents commented that the late involvement of contractors causes conflicts among stakeholders and unnecessary design changes and change orders. Documentation is the source of information which will be distributed among stakeholders. Respondents recognized the 'document control' as the third CSF with an RII value of 0.83. This is in view of prevalence to causing misinterpretations or misunderstandings of project information when various construction and project documents are controlled in an unorganized manner. Continuous improvement was the third CSF (RII = 0.78) and further emphasize the importance of efficiency in project execution. While the first two rankings were supported by Shayan *et al*. (2022), the third CSF was at variance with previous studies understandably in view of the need to mitigate effects of inflationary trends.

For the external factors category, respondents considered 'socio-cultural forces' as the most significant CSF with an RII value of 0.84. This CSF aid in defining a direction and strategy for the project team members right from the onset identifying risk issues related to social & cultural demography. In relation to the 'socio-cultural forces', respondents also emphasized the 'economic environment' as the second most significant CSF with an RII of 0.82 in view of the crucial nature of the economic situation and its effect on project risk thresholds in terms of time and budget. Thus, respondents emphasized the importance of a project direction and strategy for risk management based on the 'socio- cultural forces' and the 'economic environment'. Of the six CSFs in this category, 'project type' was the least significant with RII of 0.72. This indicated that type of project is relatively insignificant in determining an effective risk management strategy when compared to other more important CSFs. These findings are in consonance with Zhao *et al*. (2015) and Adeleke *et al*. (2015).

On a general overview of the twenty-four CSFs without regard to particular categorisation, the results revealed the top three most significant CSFs as 'project management capacity', 'early involvement of contractors' and 'knowledge and experience' with corresponding RII values of 0.96, 0.92 and 0.91 respectively. Conversely, the three least significant CSFs were found to be organisational strategy, robust risk management procedures and organisational technological capacity with RII values of 0.59, 0.56 and 0.52 respectively. While previous studies agree with the three most significant CSFs (Shayan *et al*, 2022; Zhao *et al*., 2014), ranking 'robust risk management strategy' as a least significant CSF does not agree with previous research in this subject (Liu *et al*., 2013).

CONCLUSION

In the light of the research aim of assessing critical success factors for effective risk management in an inflationary economy with clearly defined objectives, the study revealed four major categories of CSFs as 'organisational factors', behavioural factors', 'procedural factors' and 'external factors'. Each of the four categories has six number factors totaling twenty-four CSFs.

While each category has its own most significant CSF, 'project management capacity', 'early involvement of contractors', 'knowledge and experience' and 'top management support' were adjudged to be the most significant CSFs for effective risk management in an inflationary economy. These factors further support the dynamic change in risk management from project level approach to a holistic enterprise risk management (ERM) level combining the imperatives of project management capacity, knowledge and experience, early involvement of contractors with top management support.

This study covered North-western States of Nigeria with most of the participants limited to the building industry. In view of the limited scope of the study area and the research instrument, the findings should be generalised with caution. Similar studies could be extended to wider geographical area for further validation of the findings.

REFERENCES

Adeleke, A. Q., Bahaudin, A. Y., and Kamaruddeen, A. M. (2015) Level of risk management practice in Nigeria construction industry – from a knowledge based approach. *Journal of Management, Marketing and Logistics, 2,* 12-23.

Antoniou, F., Aretoulis, G., N., Konstantinidis, D., and Kalfakakou, G., P. (2012) Selection criteria used for the choice of contract type for major highway construction projects. *Procedia – Social and Behavioural Sciences, 48*, 3508-3517.

Banihashemi S, Hosseini MR, Golizadeh H, Sankaran S. (2017). Critical success factors (CSFs) for integration of sustainability into construction project management practices in developing countries. *International Journal of Project Management*. 35(6):1103–1119.

Bissonette M. 2016. ProjBorodovsky, L., & Kaushansky, A. (2019). Risk management as a tool for organizational sustainability in times of economic uncertainty. *Sustainability*, 11(23), 6574.

Carvalho, D. M., & Oliveira, A. (2020). Risk management in uncertain times: How the COVID-19 pandemic impacts organizations. *Journal of Risk and Financial Management*, 13(8), 176.

Chen YQ, Zhang YB, Liu JY, Mo P. (2012).Interrelationships among critical success factors of construction projects based on the structural equation model. *Journal of Management Engineering*. 28(3):243–251

Creswell, J. W. (2012) Educational research: planning, conducting and evaluating quantitative and qualitative research (4th ed.). Boston: Pearson Education.

Dalcher, D. (2012). The nature of project management: A reflection on the anatomy of major projects. *International Journal of Managing Projects in Business, 5*(4), 643 – 660.

El-Sayegh, S. M., and Mansour, M. H. (2015) Risk assessment and allocation in highway construction projects in the UAE. *Journal of Management in Engineering*, 31,1-11.

Financial Derivatives Company (2022). Monthly financial bulletin, vol. 12 (19), page 10-12

Financial Derivatives Company (2023). Bi-monthly financial bulletin, vol. 13 (8), page 10-15

Hillson, D. (1997) Towards a risk maturity model. *International Journal of Business Risk Management, 1*, 35-45.

Hoseini, E., Bosch-Rekveldt, M and Hertogh, M. (2018) *Risk management maturity of construction projects in the Netherlands.* Paper presented at the In: Gorse, C and Neilson, C J (Eds) Proceeding of the 34th Annual ARCOM Conference, 3-5 September 2018, Belfast, UK, Association of Researchers in Construction Management, 657-666.

Hwang, B., Zhao, X., and Toh, L., P. (2014) Risk management in small construction projects in Singapore: status, barriers and impacts. *International Journal of Project Management, 32*, 116-124.

Imbeah, W. & Guikema, S. (2009) Managing construction projects using the advanced programmatic risk analysis and management model. *Journal of Construction Engineering and Management* 135: 772-781.

Liu, J., Zou, P., and Gong, W. (2013) Managing project risk at enterprise level: exploratory case studies in China. *Journal of Construction Engineering Management, 139*, 1268-1274.

Loosemore, M., Raftery, J., Reilly, C., and Higgon, D. (2006) *Risk management in projects* (Second ed.). New York: Taylor and Francis.

Monetti, E., Rosa da Silva, S., A., and Rocha, R., M. (2006) *The practice of project risk management in government projects: a case study in Sao Paulo city*.

PMI. (2013) *A guide to the Project Management body of knowledge*.

Price Waterhouse Coopers (2020). Managing risks and uncertainty during COVID-19. Retrieved from https://www.pwc.com/us/en/library/covid-19/managing-risks-and-uncertainty-during-covid-19.html

Rivera, A., Le, N., Kapsikar, K., Kashiwagi, J., & Ph, D. (2017). Identifying the Global Performance of the Construction Industry, 567–575.

Rodrıguez-Segura E, Ortiz-Marcos I, Romero JJ, Tafur-Segura J. (2016). Critical success factors in large projects in the aerospace and defense sectors. *Journal of Business Resources* 69(11): 5419–5425.

Shadi Shayan, Ki Pyung Kim & Vivian W. Y. Tam (2022) Critical success factor analysis for effective risk management at the execution stage of a construction project, *International Journal of Construction Management*, 22:3, 379-386, DOI: 080/15623599.2019.1624678

Serpell, A., Ferrada, X., Rubio, L., and Arauzo, S. (2015) Evaluating risk management practices in construction organizations. *Procedia – Social and Behavioural Sciences, 194*, 201-210.

Simoni, M. M., & Boland, N. (2019). Effect of inflation on construction costs. *Journal of Construction Engineering and Management,* 145(12), 04019106.

Tah, J. & Carr, V. (2000). Information modelling for a construction project risk management system. Engineering, Construction and Architectural Management 7: 107-119.

World Bank Group. (2017). Infrastructure and Economic Growth. Retrieved from https://openknowledge.worldbank.org/bitstream/handle/10986/26447/114715-WP-PUBLIC-Infrastructure-Economic-Growth.pdf

World Economic Forum. (2016). Shaping the Future of Construction: A Breakthrough in Mindset and Technology. Retrieved from https://www.weforum.org/reports/shaping-the-future-of-construction-a-breakthrough-in-mindset-and-technology

Yong Y. C. & Mustaffa, N. E. (2017). Critical success factors for Malaysian construction projects: An investigative review. Journal Alam Bina. 4(2):93–104.

Zavadskas, E.K., Turskis, Z. & Tamošaitiene, J. (2010). Risk assessment of construction projects. *Journal of Civil Engineering and Management* 16: 33-46.

Zhao, X., Hwang, B., Low, S., P., and Wu, P. (2015) Reducing hindrances to enterprise risk management maturity in construction firms. *Journal of Construction Engineering and Management, 141*, 1-10.

Zhao, X., Hwang, B., and Low, S., P. (2014) Investigating enterprise risk management maturity in construction firms. *Journal of Construction Engineering and Management, 140*, 1-10.

Zhao X, Hwang B-G, Low SP. (2013). Critical success factors for enterprise risk management in Chinese construction companies. Journal of *Construction Management Economics* 31(12):1199–1214.

Zou, P., X., , Chen, Y., and Chan, T. (2010) Understanding and improving your risk management capability: assessment model for construction organizations. *Journal of Construction Engineering and Management, 136*, 854-863.

A CRITICAL REVIEW OF FLEXIBLE PAVEMENT FAILURE IN NIGERIA: CAUSES AND REMEDIES

Onyenenue Destiny OSUYA
Department of Civil Engineering, Obafemi Awolowo University
Email: onyenenue2016@gmail.com, Phone number: 234 7038005502

ABSTRACT
The failure of flexible pavements in Nigeria within few years of construction has drawn the attention of Highway Engineers. This has raised some serious questions on the durability of Nigerian roads. This paper reviews the causes of flexible pavement failures and provides some remedies that could improve the performance and durability of Nigerian roads. Some of the identified causes of failures by some research are: non-engagement of highway and pavement experts; lack of proper corridor study, site investigation, and geotechnical survey; improper pavement design; poor supervision and monitoring; lack of drainage facilities; lack of timely and periodic maintenance; lack of sanctions for those responsible for highway failures. This paper further identified moisture susceptible pavement materials as one of the major causes of failures. Some of the suggested remedies by some researchers are: provision of proper pavement designs; proper corridor study, site investigation, and geotechnical survey; engagement of experts in highway and pavement engineering; proper supervision and monitoring; preventive and routine maintenance of roads; provision of drainage facilities; and government enforcement of sanctions. This paper further suggested the following remedies: use of anti-stripping additives; good remuneration for experienced and registered Engineers; establishment of state pavement research institutes; and establishment of direct labour agencies. With these remedies; and the highway agencies playing their roles, Nigeria can have durable flexible pavements.

1.0 INTRODUCTION

The Nigerian highway system will be required to accommodate increasing numbers of motor vehicles during the coming decades due to increasing population, technology, and industrialisation. Accordingly, rehabilitation of the existing system will become a major activity for highway and transportation agencies. A good road network system is perhaps one of the most important necessities for the economic development of any country, particularly developing countries. Many developing countries, therefore, invest huge amount of money on road construction, and appreciate the necessity for huge investment in capital development of roads (Kishore and Ramu, 2020). Road is an important infrastructure in a nation or community of people. It greatly affects the economy of any nation (Oluwatobi, 2010). Roads are built to provide safe passage of vehicles and must be properly designed and constructed (Afolayan and Abidoye, 2017). In the developing countries such as Nigeria, road network is the most developed transport mode and the vastest in usage (Okigbo, 2012). Roads represent the major areas of investment in transportation, and are also the dominant travel mode accounting for over 90 % of passenger and goods transport in Nigeria (Oguara, 2010). Road transportation immensely contributes to the economic, industrial, social and cultural development of any country. Road transportation is vital for the economic development of any region since every commodity produced whether it is food, clothing, industrial products or medicine needs transport at production and distribution stages. The inadequate transportation facilities retard the process of socio-economic development of the country. The adequacy of the transportation system of a country indicates its economic and social development (Kishore and Ramu, 2020). Durable transportation infrastructure results in saving billions of Dollars in maintenance cost (savings for federal, state, local, and city highway agencies), reduced vehicle operating cost and travel time (savings for traveling public), and an improved safety for the society (savings for highway agencies, traveling public, insurance companies among others) (Gedafa and Suleiman, 2018).

The failure of asphaltic concrete pavement under traffic loading and environmental conditions within few years of construction has drawn the attention of Highway Engineers in Nigeria; and a lot of concerns have been raised. The issue of dilapidated roads across the country is a difficult challenge of which solutions do not seem to be in sight. This is because the failure of roads has continued to pose serious dangers to motorists due to the deplorable state with attendant recorded accidents and economic losses

to the populace especially as a result of loss in man hours arising from delays on several bad portions of the roads. This daunting challenge is hampering investments in the industrial sectors which has over the years led to the shutting down of many industrial firms. From the difficulty of accessing raw materials due to bad roads, to vehicular breakdowns which necessitate routine repairs, it is increasingly becoming difficult to plan production in the industrial sectors. This challenge has corresponding negative effects on the health care services accessibility between areas with bad roads and the agricultural products and marketing. This does not augur well for the economy, as it is a major hindrance that investors are worried about; and with associated increase in the costs of production, there is need for improved and durable road infrastructure. The roads in major states in Nigeria are in terrible and deplorable condition and there is an urgent need to address the challenges (Guardian Nigeria, 2020). One interesting fact is that Nigeria has all the human and material resources to overcome the challenges of road failures.

2.0 CAUSES OF FLEXIBLE PAVEMENT FAILURES IN NIGERIA

Roads are considered as the lifeline of any country. Some of the important roles of roads in Nigeria economy are: connection to villages and cities; industrial development; carriers of freight and passengers complementing the railways; agricultural development; and administrative convenience. Engineers have always been open minded to adopt any technically improved method available to them for its use for construction and maintenance purposes. It is logical to see that the purpose of highway construction is to provide a firm and even surface for the carriageway or the pavement which could stand the stress caused due to number of load applications (Kishore and Ramu, 2020). An asphalt pavement has the function of carrying traffic safely, smoothly, and economically between locations. However, there are certain factors that can negatively affect the performance of asphalt pavements. These factors can cause a reduction to the pavement's strength and serviceability, which lead to either failure or severe damage (Al- Mosawe, 2016).

Some of the factors in addition to moisture susceptible materials responsible for the poor performance and failure of flexible pavements in Nigeria as identified by Osadebe *et al.,* 2013; Ndefo, 2012; Oluwatobi, 2010; Okigbo, 2012; and Afolayan, and Abidoye, 2017 are:

a. Non-engagement of highway and pavement experts

Often times non- professionals in pavement engineering are given the jobs of constructing the high trafficked highways in Nigeria. They may have certain knowledge of road construction but are not experts. The highway Engineer understands the highway pavement from planning, designing, construction, and maintenance. He has the experience and requisite knowledge to handle any condition arising from difference in design and field data both material and soil.

b. Lack of proper corridor study, site investigation, and geotechnical survey

From the point of conception of some roads projects, there is no proper study and testing of the subgrade to determine the physical properties and chemical composition, no proper information on the hydrological properties of the area in order to propose a functioning drainage system and no corridor study of the project area. The effect of this is either poor design as a result of the use of assumed geotechnical data or road construction without design.

c. Lack of drainage facilities

Lack of drainage structures especially in areas with extreme rainfall and high water table causes road failures. In some cases, there may be drainage channels which are not properly constructed. The absence of weep holes which drain subsurface moisture from the road area subject the road to hydrostatic pressure and if the pressure is too much, the moisture may infiltrate into the road base and wearing course and cause damage.

d. Improper pavement design

There are four stages involved in pavement design: geometric, thickness, asphalt concrete materials, and drainage. When there is little or no design for a road with respect to the four stages, there will be failures. When there is little or no traffic survey, there will be errors in thickness design. Even when design is carried out, it applies to only a section of the road. Soil properties are usually variable within a particular length of road. The material thickness for a section that has different soil properties from another section cannot be the same. Due to inadequate projection, most roads today are overloaded and are failing because they were not designed to carry the traffic loads they are subjected to. Due to technology and industrial development, there has been increase in the number of heavy duty vehicles with high tire pressure on the road. Some of the mentioned criteria are not taken into account in the course of pavement design in Nigeria.

e. Poor supervision and monitoring

In the absence of proper monitoring and supervision, contractors do not follow the standard construction procedures and no strict adherence to the design specifications and details. A good pavement design with good detailing without a good supervision by the designer (consultant) is equally useless as this could lead to road failure (Osadebe *et al.*, 2013).

f. Lack of timely and periodic maintenance

A major problem that faces highway and transportation infrastructures is the lack of repair and rehabilitation of every roadway section that deteriorates. The problem is further complicated in that roads may be in poor condition but are still usable, making it easy to defer repair projects until conditions become unacceptable. When preventive maintenance is neglected, roads will begin to deteriorate such that the basis for rehabilitation will be the extent of complaints by road users. The traveling public is unwilling to tolerate pavements that are extremely rough and cause vibration and severe damage to their vehicles (Garber and Hoel, 2009). Poor quality pavements may lead to accidents and increase in user costs.

g. Lack of sanctions to those responsible for highway failures

Premature roadway deterioration is sometimes not usually the result of poor design and construction practices but is caused by the inevitable wear and tear that occurs over a period of years. Usually, the gradual deterioration of a pavement occurs due to many factors including variations in climate, drainage, soil conditions, and truck traffic (Garber and Hoel, 2009). In Nigeria, the situation is different. Pavement failures are sometimes caused either by government agencies, the contractors or the road users. There have been records of failures on Nigerian highways. No body or agency has ever been held responsible (Ndefo, 2012). Adequate sanctions and penalties are not in place to monitor agencies responsible for supervision and the contractor in cases of road failure. When accidents occur in a bad road, the contractors and agencies involved in the construction are not always sanctioned, though the accident may have been avertable or its fatality at least reduced on good roads and the blame is always placed on the driver. Also, road users are not punished for damage or misuse of roads. This has made the supervisory agencies, contractors and road users to contribute in road failure without any fear of sanctions (Afolayan and Abidoye, 2017).

h. Moisture susceptible pavement materials

Research has shown that some materials (bitumen and aggregates) used in most countries are susceptible to high temperatures and moisture due to their chemical composition. The most widely used materials in Nigerian road construction are not resistant to extreme temperatures and moisture condition. Due to climate change, the world is experiencing variation in environmental conditions. The softening point of 60 -70 penetration grade bitumen widely used in Nigeria is between $48 - 56\ ^{\circ}\mathrm{C}$. At very high temperatures, bitumen flows and oxidation occurs; and some of the volatile compounds evaporate, making it to lose some of its properties (Asphalt Institute, 2001; Domone and Illston, 2010).

Also, at high moisture condition, water penetrates into the asphalt concrete through interconnected air voids and cracks. Water enters the bitumen and dissolves the soluble compounds within bitumen (Terrel and Al-Swailmi 1994; Kanitpong and Bahia 2003). This causes the bitumen to lose some of its properties and hence the binding power resulting in cohesive and adhesive failures. The loss of cohesive and adhesive bonds leads to the stripping of the bitumen and hence moisture damage. This is manifested in the form of different distresses such as rutting, cracking, raveling, and shoving. Also, the granite aggregate mostly used in production of HMA consists mainly of silica which makes it acidic and hydrophilic (Tarrer and Wagh, 1991). Also, siliceous aggregates do not form moisture resisting compounds with bitumen, unless, the bitumen contains alkaline amine compounds (Little and Jones, 2003). Siliceous aggregates being acidic, they do not respond to the action of the naphthenic acids in the bitumen. In fact, the acids counteract each other and a good bond between a siliceous aggregate and bitumen is difficult to obtain (Tarrer and Wagh, 1991).

REMEDIES FOR FLEXIBLE PAVEMENT FAILURES IN NIGERIA

Preserving as well as managing the nation's highways is a challenge, and transportation professionals are investigating tools and techniques to assist in this endeavour. Some of the remedies to the failures of asphalt concrete roads are as follow:

a. **Use of anti-stripping additives**

When materials used for HMA fail within few years of construction due to the combined effects of traffic loads and environmental condition, there is a serious concern. When water sensitive pavements are exposed to moisture, deterioration to the pavement may be fast tracked. This would result in a pavement with reduced performance and service life; and an increase in the maintenance costs (Ravi Shankar, *et al*, 2018). To alleviate or control this problem, various liquid or solid anti-stripping additives have been developed, which can be used to promote adhesion between asphalt binder and aggregate (Hunter and Ksaibati, 2002). The use of anti-stripping additives is a very effective and popular method for reducing the stripping potential of asphalt mixes. They usually minimize the moisture damage by increasing the adhesion at the aggregate-asphalt interface. The most important function of an anti-strip additive is to eliminate the moisture sensitivity of the HMA mixture by improving the bond between the asphalt binder and the aggregates, and maintaining desirable properties of the mixture (Ravi Shankar, *et al.,* 2018). Anderson and Dukatz (1982) experimental studies of the physical and compositional properties of asphalt cement with anti-stripping additives demonstrated that anti-stripping additives tend to soften asphalt, reduce temperature susceptibility, and improve the aging characteristics of asphalt cement.

1. Use of amine

Liquid anti-stripping agents are chemical compounds that generally contain amines and can affect the engineering properties of the aggregate, asphalt binder or the resulting asphalt mixture. The effectiveness of the liquid anti-strip on the water sensitivity of the hot mix asphalt mixture depends on the physicochemical properties of the asphalt binder and the aggregate, as well as on the amount of liquid anti-strip agent used. Most anti-stripping agents reduce surface tension between the asphalt and aggregate in a mixture. When surface tension is reduced, increased adhesion of the asphalt to the aggregate is promoted. Thus, most liquid anti-stripping agents are surface-active agents (Hunter and Ksaibati, 2002). Amine compounds present in asphalt or added in the form of anti-stripping agents will react with acidic surfaces as in the case of siliceous aggregates to form a surface compound as shown in equation 1 and Figure 1 (Little and Jones, 2003).

$$\text{--SiOH} + \text{RNH}_2 \rightarrow \text{--SiO}^- \text{RN}^+\text{H}_3 \quad (1)$$

Siliceous aggregate **Amine compound** **Insoluble compound**

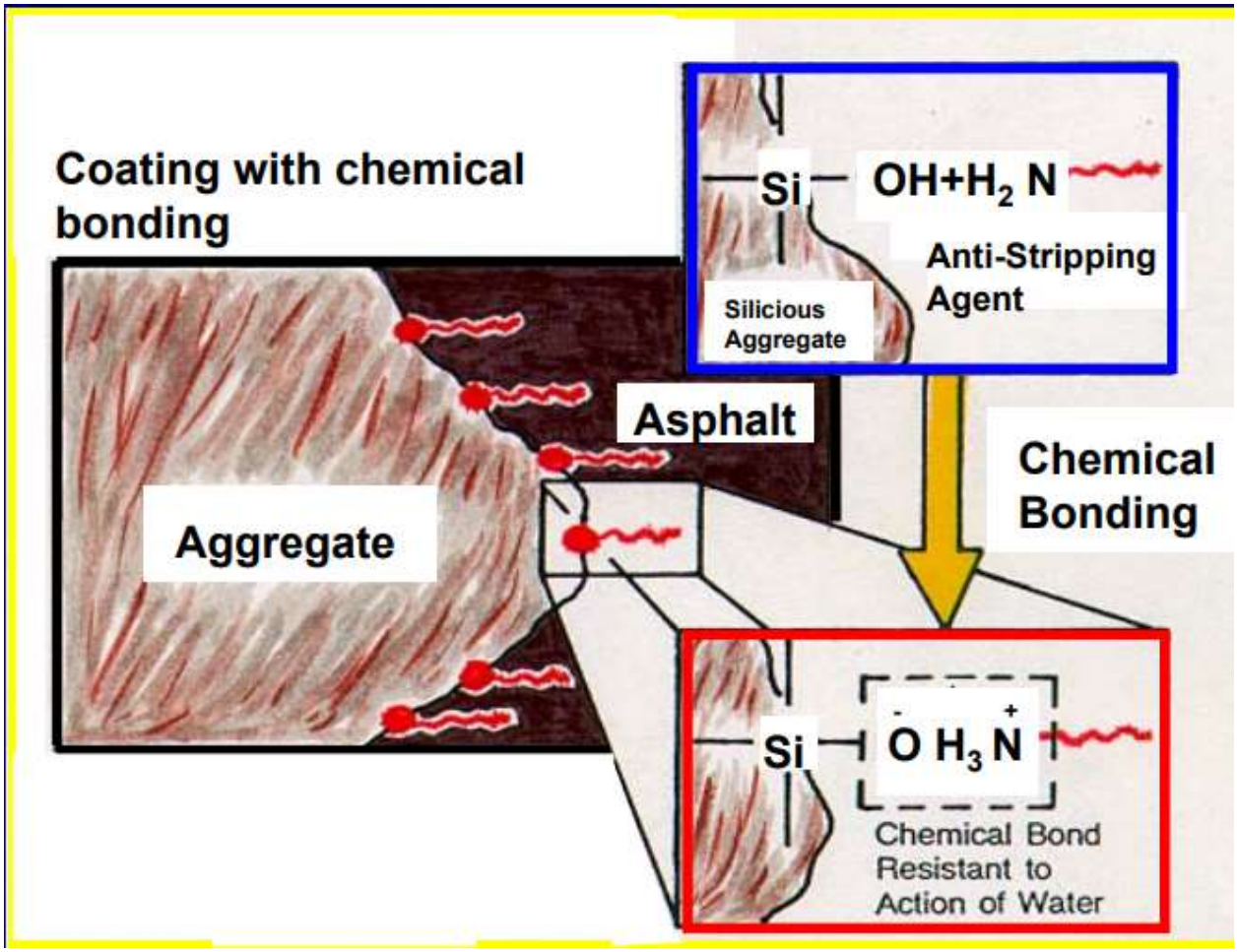


Figure 1. Reaction of Siliceous Aggregate with Amine Component in Bitumen

Aggregates have a natural affinity for water and hence untreated aggregates are much more likely to be damaged by water breaking the asphalt-aggregate bond. Liquid anti-stripping additives allow the asphalt cement to create a strong bond between the asphalt and aggregate. Most of the liquid anti-stripping additives are added to the heated asphalt binder prior to its application onto the aggregates and can be mixed with large amounts of asphalt and stored for use before mixing. A disadvantage of the liquid additives is that they are usually deteriorated with prolonged heating (Tayebali *et al.*, 2003). The addition of one half to one percent of the amine by weight of the asphalt binder can result in improved moisture resistance due to the reduced surface tension of the asphalt binder, resulting in an improved asphalt – aggregate bond (Rosner *et al.*, 1981)

2. Lime

The application of lime is one of the most common methods of minimizing moisture susceptibility of flexible pavements. Both hydrated lime $Ca(OH)_2$ and quick lime (CaO) are effective at preventing stripping in HMA mixes, although the former is most commonly used. Based on previous research, the addition of hydrated lime to asphalt mixtures improved the adhesive bond between the aggregate and bitumen, substantially reducing the occurrence of stripping (Hunter and Ksaibati, 2002; Ravi Shankar

insoluble compound (Little and Jones, 2003).

$$CaO + 2RC00H \rightarrow (RC00^{-})_2 Ca + H_2O \quad (2)$$

Lime Carboxylic acid Insoluble salt Water

Further research identified chemical reactions that occurred between lime and most bitumen that reduced their affinity for water, in turn reducing the mixture's tendencies to strip. In addition, when aggregates are coated with clays, hydrated lime can react to remove the deleterious materials that would otherwise damage the mixture (TRB, 2003). The effect of hydrated lime on the moisture sensitivity of asphalt mixes can also be viewed in a mechanical perspective. Hydrated lime, which is an extremely fine filler, helps to stiffen the asphalt mixture. Consequently, the lime increases the rutting, fatigue, and moisture resistance (Ravi Shankar *et al.,* 2018). . 1.0 % hydrated lime by weight of total dry aggregates in a mix is typically applied to HMA used in US pavements (Kim *et al.*, 2012).

3. Use of hydraulic cement

Hydraulic cement is the most widely used construction material that is manufactured in the world. Although, hydraulic cement has not been widely utilized in asphalt concrete, it is sometimes recommended as filler when asphalt concrete is likely to fail due to rutting and moisture damage. The chemical composition of hydraulic cement makes it an effective material to improve the rutting and moisture damage resistance of asphaltic concrete. The wide usage of hydraulic cement in concrete and soil stabilization puts significant confidence in utilization of hydraulic cement reactive powders in asphaltic pavements. According to (Mondal and Hossain, 2020; Rosner *et al.*, 1981) incorporating as low as 1 % - 2 % of ordinary Portland cement as mineral filler increases the strength and tensile properties, and also the stripping resistance of the pavement material. Although this is bound to increase the pavement construction cost by a nominal amount, however, huge maintenance cost can be reduced significantly with this minimal initial cost increase.

4. **Use of by-products**

When the use of lime and hydraulic cement increases the cost of production of HMA, then, the use of affordable and economical materials is desirable. Such materials are by-products that have shown promising results to improve the performance of HMA subjected to traffic loads and environmental conditions.

4.1 **Fly ash**

Fly ash is a by-product of the coal combustion process. Carbon and most volatile materials are burned off by burning pulverized coal in electric power plant. Recently, the use of alternative additives such as fly ash has driven significant attention to the asphalt materials/pavement community because fly ash is much more economical and convenient to access than hydrated lime in certain countries. The improvement of moisture-damage resistance by adding fly ash to the asphalt mixture was also shown by Dougan (1996). Ali *et al.* (1996) stated that fly ash added in the amount of 2 % of total weight of aggregates as mineral filler improves not only the stiffness characteristics, but also mixture strength and stripping resistance.

b. **Provision of proper pavement design**

A good and functioning road is a product of a good design. The construction of a road starts from conception, planning and design. The different stages of design (geometric, thickness, asphalt concrete materials, and drainage) must be completed for proper and acceptable design. Proper details on alignments, traffic volume, design vehicle, speed, and construction material properties should be used for any road design. In developed countries, mix design is done using SUPERPAVE (superior performing asphalt pavement). Contractors in Nigeria both foreign and local should have the modern testing equipments to carry out asphalt concrete performance tests such as rutting and moisture damage. Hydrological properties and drainage patterns of the corridor should be obtained and design carried out accordingly.

c. **Proper corridor studies, site investigation, and geotechnical survey**

Usually, because of cost implication, these activities are not properly carried out. Thus, the design will not take into account certain details that would have made it good. Proper corridor study will help to determine the best position to locate the road in terms of economy, usefulness, and durability. Proper study of the topography of the project route will provide some insight into the drainage patterns and existing facilities. Review of project specific geotechnical data is imperative, as it will provide insight into: existing ground conditions; properties of materials to be excavated; and if dewatering will be necessary for below grade work; if shoring will be required to protect excavations.

d**. Provision of drainage facilities:** reinforced concrete line drain, wells; and vertical sand drain

In areas where the roads are located in a water bearing formation, the provision of adequate drainage facilities will reduce total water content of the subgrade, knowing perfectly well that excess water reduces supporting power of the soil. Special attention must be given to areas that are suspected to have high water content; and proper and efficient drainage facilities must be constructed or installed where necessary. The soil condition must be investigated properly and the most effective and efficient drainage facilities should be used.

e. **Engagement of experts in highway and pavement engineering**

Experts from Universities, Polytechnics, and research institutes should be engaged in the planning, design, construction and maintenance of road infrastructures. Also, all construction companies must engage at least two experienced and registered Engineers before they are awarded any road project. Through this, standard materials specification and construction procedures will be guaranteed. For companies that do not have asphalt plant, they need qualified Engineers to check the quality of the job mix supplied to them, which is usually compromised if not monitored.

f. **Good remuneration for experience and registered Engineers**

Engineers should be well paid and welfare given due consideration. One of the problems of the construction industries in Nigeria is the poor remuneration for experienced Engineers. This occurs especially with indigenous companies. This affects negatively the quality of supervision and construction procedures; and the material specifications are compromised in some situations.

g. Establishment of direct labour agencies

The establishment of direct labour agencies in every Local Government Area with relevant asphalt concrete construction materials and equipments is very important to preventive and corrective maintenance. With the availability of construction materials and equipments, the repair of damaged portions of the road will be much easier and faster. Qualified Engineers should be employed with well-trained support staffs in the line of asphalt concrete technologies both of hot mix asphalt (HMA) and warm mix asphalt (WMA) and pavement maintenance.

h. Preventive and routine maintenance of roads

The government agencies vested with the role of road maintenance must be proactive. Timely maintenance will not only ensure that roads are always in good condition but also protect other road sections from failure (Afolayan and Abidoye, 2018). Maintenance should be carried out if there is emerging signs of road failure. There should be routine checks on State and Local roads to know if any portion of the road has the tendency to fail. If noticed, the cause of failure should be properly investigated, identified, and the road repaired. Some areas may experience structural failure, and require the stabilization of the underlying soil before the placement of HMA.

i. Establishment of state pavement research institutes

The establishment of pavement research institute in every State of the country will go a long way in improving the quality and number of researches in road engineering. Through these researches, causes associated with failures in a particular corridor will be properly investigated, materials will be tested, and modification made according to recommendations.

j. Government enforcement of sanctions

Regardless of the agency, contractor, or roader users, anyone found wanting should be punished to act a re c

k. Proper supervision and monitoring

A well designed road, without adequate supervision, does not guarantee a well-constructed road. Necessary laboratory and In-situ tests should also be carried out to ensure that construction of roads are carried out according to specifications. Quality in road construction and maintenance can only be

achieved by controlling all features and characteristics that will impact desired quality on the road and that good quality tested material cannot be overemphasized (Afolayan and Abidoye, 2018).

CONCLUSION AND RECOMMENDATION

Most Nigerian roads would be durable if Highway and Transportation Engineers are engaged in the planning, design, construction, and maintenance. Also, highway and transportation agencies saddled with the road monitoring and maintenance responsibilities should play their own part in making sure that roads are always in good condition. If funds becomes the challenge as sometimes experienced, local suitable and accessible materials should be used to augment other conventional construction materials and in that way, timely maintenance can be carried out and total failure of roads will be avoided.

REFERENCES

Ali, N., Chan, J.S., Simms, S., Bushman, R., and Bergan, A.T. (1996). Mechanistic evaluation of fly ash asphalt concrete mixtures. *Journal of Materials in Civil Engineering*, 8 (1): 19-25.

Al-Mosawe, Hasan (2016). *Prediction of permanent deformation in asphalt mixtures*. PhD thesis, University of Nottingham. 4 -5.

Afolayan, O. D. and Abidoye, A. O. (2017). Causes of Failure on Nigerian Roads: A Review. *Journal of Advancement in Engineering and Technology.* 5 (4), 2348-293

Anderson, D. and E. Dukatz (1982). The Effect of Anti strip Additives on the Properties of Asphalt Cement. *Association of Asphalt Paving Technologists*, Vol. 51, pp 298-317.

Asphalt Institute. (2001). "Superpave Mix Design". *Superpave Series No. 2 (SP-02*). Asphalt Institute. Le.xington, KY.

Bi, Y. C. and Jakarni, F. M. (2019). Evaluating properties of wood ash modified asphalt mixtures. IOP Conference Series: *Materials Science and Engineering 512, 012004 IOP Publishing doi:10.1088/1757-899X/512/1/012004*

Garber, N. J. and Hoel, L. A. (2009).*Traffic and Highway Engineering*. Fourth Edition. Cengage Learning, University of Virginia, USA, 1133 – 1135.

Gedafa, D. S. and Suleiman, N. (2018). Investigating the Use of Fly Ash for Sustainable Asphalt Pavements. Research Proposal, Department of Civil Engineering, University of North Dakota. 1-19.

Guardian Nigeria (2020). Bad Roads and Lagos – Ogun Industrial Corridors, Editorial, 26 August. *htts://guardian.ng/opinion/bad-roads-lagos-ogun-industrial-corridors/*

Hunter E.R. and Ksaibati K. (2002). *Evaluating Moisture Susceptibility of Asphalt Mixes*. Department of Civil and Architectural Engineering, University of Wyoming, Laramie, Wyoming.

Kanitpong, K. and H.U. Bahia. (2003). Role of Adhesion and Thin Film Tackiness of Asphalt Binders in Moisture Damage of HMA". *Journal of the Association of Asphalt Paving Technologists*, 72: 502-528.

Kim, Y. R., Pinto, I. and Park, S. W. (2012). Experimental Evaluation of Anti-stripping Additives in Bituminous Mixtures through Multiple Scale Laboratory Test Results. . *Construction and Building Materials.* 29, 386–393

Kishore, G. R. and Ramu, K. (2020). Evolution of Highway Failures and Their Maintenance.*International Research Journal of Engineering and Technology (IRJET).* 7 (7), pp 3156 – 3157.

Mixed Asphalt Pavements. *Transportation Research Records*, California.A National Seminar,37 – 70.

Ndefo, O (2012). Causes of Highway Failure in Nigeria. *International Journal of Engineering Science and Technology*, 4 (11).

Oguara, T. M. (2010). A management model for road infrastructure maintenance. *Book of Proceedings, 19th engineering assembly, Council for the regulation of engineering in Nigeria.*

Okigbo, N. (2012). Causes of Highway Failures in Nigeria. *International Journal of Engineering Science and Technology*, 4 (11), 4695-4703

Oluwatobi, S. (2010). Investigation into Causes of Failure along Nigerian Roads: A case study of Ibadan – Ife Express way, Unpublished, University of Ibadan.

Osadebe, C.C., Fakeye, A.M., Matawal, D.S. & Aitsebaomo, F.O. (2013) Road Pavement Failure in Nigeria: A Case Study of Enugu-Port Harcourt Expressway. *22nd National Engineering Assembly* on 20th August, 2013.

Osuya, O. D. and Mohammed, H. (2017). Evaluation of Sawdust Ash as a Partial Replacement for Mineral Filler in Asphaltic Concrete. *Ife Journal of Science*, 19 (2), 431 – 440.

Ravi Shankar, A.U., Goutham S., Lekha, B M, and Calvin, C-C. (2018). Investigation on the Effect of Anti Stripping Additives on the Moisture Sensitivity of Bituminous Concrete. Conference Paper: *https://www.researchgate.net/publication/318462571*. Pp 1 – 14.

Rosner. J. C, Paviovich R. D, Chehovits, J. G. (1981). Fly Ash as a Mineral Filler and Anti Stripping Agent for Asphalt Concrete. *Report Number: FHWA/AZ-81/173*, Arizona Department of Transport. Pp2

Tayebali A.A., Fischer W.K., Huang Y.X., Kulkarni M.B. (2003). Effect of percentage baghouse fines on the amount and type of anti-stripping agent required to control moisture sensitivity. *Report No. FHWA/NC/2003-04*. Department of Civil Engineering, North Carolina State University, Raleigh, North Carolina.

Transportation Research Board (TRB), (2003). *Moisture sensitivity of asphalt pavements*. A National Seminar, San Diego, California.

Tarrer, A. R., and Wagh, V. (1991). The Effect of the Physical and Chemical Characteristics of the Aggregate on Bonding. *Strategic Highway Research Program, National Research Council*, Washington, D.C.

Terrel, R. L., S. AL-Swailmi. (1994). "Water Sensitivity of Asphalt-Aggregate Mixes: Test Selection". Washington, D. C.: Strategic Highway Research Program, *SHRP-A-403*, National Research Council.

FOSTERING LEARNING ENVIRONMENTS: ARCHITECTURAL SPACE DYNAMICS AND STUDENT ENGAGEMENT CHALLENGES IN FACULTY OF ARCHITECTURE DESIGN

Ogundele Joseph Olurotimi [1], Utibe Emmanuel Akah [2], and Usen Peter Udoh [2]
[1]Department of Architectural Technology, Bida, Niger State; 08119816244, josog2009@gmail.com
[2]Department of Architecture, Faculty of Environmental Studies, University of Uyo, Uyo

Abstract
This study delves into the realm of architectural education, specifically focusing on the dynamic interplay between spatial design and students' interaction and performance. With focus on the Nigerian educational landscape, the research critically explored the architectural spaces that are pivotal to enhance students' engagement and achievement. Through a comprehensive analysis, the study unveiled the critical significance of spaces such as lecture halls, design studios, seminar halls, and exhibition spaces in shaping the educational experience. Yet, this investigation went beyond mere spatial considerations. It delved deep into the challenges that often impede the seamless flow of student interaction and hinder optimal performance. From poor student interaction to quality assurance concerns, the study uncovered the multifaceted barriers that students encounter in their educational journey. Proposing actionable recommendations, the study advocates for the harmonization of architectural spaces and the enhancement of student satisfaction. It emerges as a clarion call to stakeholders in education and the built environment, urging them to collaborate in crafting an environment that not only facilitates learning but also fosters vibrant interactions and elevated academic achievements. In a nutshell, this research unfurls the intricate relationship between architecture and education, demonstrating how thoughtfully designed spaces can revolutionize student interaction and performance. It offers valuable insights for educators, designers, and policymakers to create learning environments that empower and inspire the next generation of architects and scholars.

Keywords: *Architectural Education, Performance Enhancement, Spatial Design, and Students Interaction*

INTRODUCTION

Education's role in national development is universally acknowledged (Onyal and Nnebedum, 2021). It drives progress across economic, political, and social dimensions (Eduwen & Osagie-Obazee, 2016). Tertiary institutions are crucial in disseminating knowledge and advancing society (Asaju & Adagba, 2014). Nigeria's education sector faces infrastructure challenges, despite increased enrollment (Ogbu & Imafidon, 2020). Facility harmonization, including lecture halls and offices, impacts education quality (Woldegiyorgis, 2018). Yet, architectural faculties lack harmonization, hindering student interactions (Ogbu & Imafidon, 2020). This issue is amplified in architecture, requiring specialized spaces (Woldegiyorgis, 2018). Bridging this gap is vital for dynamic learning.

This study aims to comprehensively analyse the architectural spatial requirements for the design of a faculty of architecture for enhanced student interaction and performance within the Nigerian educational. The objectives are to; 1) Identify pivotal spaces within architectural departments and 2) Investigate the barriers militating students interaction and performance. The study enriches architectural education and guides future designs.

REVIEW OF RELATED LITERATURE

Architectural Spatial Requirements for Faculty Facilities

The reviewed literature underscores the role of architectural spaces in shaping social interactions and practices among students (Lefebvre, 1991; Massey, 1994). Learning spaces influence teaching and learning dynamics, impacting student outcomes (Oblinger, 2006). The relationship between space and learning isn't linear; however, spaces do mediate conditions that can enhance learning (physical, mental, cognitive) while blurring real and virtual distinctions. Design shapes space, which can foster or hinder interactions (Lekjep, 2017). Space, created by physical boundaries, can bring people together or separate them, impacting relationships (Lawson, 2001). Architectural spaces consist of "Spatium" and "Extensio", created by natural and artificial elements (Lawson, 2001).

Spatial dimensions differ based on activity (Savanjala, 2010). Flexible learning spaces aligned with student-centered approaches improve interaction and engagement. Flexibility extends to office design, often favoring open-plan offices (Charles et al., 2004). Movement experiences—passage, junction, and place—contribute to understanding architectural space (Savanjala, 2010). Flexible spaces, both historically used and recent in educational settings, enhance interactions and learning experiences (Karns, 2006).

Factors affecting student learning outcomes encompass physical well-being, cognitive, affective, and behavioral characteristics (Hattie, 2009). Teacher-student interactions and leadership play crucial roles (Mulford, 2005). The built environment is one of multiple factors influencing learning outcomes (Bowen et al., 2008).

Challenges Affecting Student Interaction and Performance

The review in this section examines challenges impacting student interaction and performance in tertiary institutions. Poor learning facilities negatively affect satisfaction and performance (Oluwunmi et al., 2017). Harmonized facilities positively influence interaction (Islam and Sanzida, 2021). Challenges include technology integration, learning approaches, social interaction (Casanova and Price, 2018), motivation, feedback, tutor knowledge (George and Walker, 2017), and lack of interest in design (Islam and Sanzida, 2021). Fook and Sidhu (2015) found cognitive challenges, instructional problems, language barriers, time management, assignment burden, and cultural differences affecting interaction. Facilities' inadequacy hampers interaction (Olufemi et al., 2018). Noisy environments hinder interactions (Islam and Sanzida, 2021), and quality concerns affect learning (Azeiteiro et al., 2015). Lack of guidance, network quality, and poor harmonization disconnect students (Alnusairat et al., 2020; Banfegha, 2014). Poor funding impacts quality (Eduwen and Osagie-Obazee, 2016).

Digital fluency, satisfaction, and feedback delays affect interaction (Alnusairat et al., 2020). Inadequate facilities hinder skill development (Asiyai and Okoro, 2019). Water, electricity, funding issues, overcrowding affect performance (Akhihiero, 2011; Arisi, 2002; Ready et al., 2004). Built environment neglect and external factors lead to disengagement (Blackmore and Kamp, 2008). Poorly designed schools impact morale (Filardo, 2008). Learning indicators include test scores, engagement, social interactions, well-being, behavior (Tanner, 2009).

Summary of Review of Related literature

Several studies have examined student-faculty interactions across the globe (Umbach and Wawrzynski, 2005; Cox *et al*., 2010; Cho and Auger, 2013; Tatum *et al.*, 2013). Effective interaction provides satisfaction, mutuality, trust and commitment among students and this could improve faculty of architecture performance (Cho and Auger, 2013). Tatum *et al*. (2013) revealed interactions in the classroom frequently help in developing adequate skills. Interactions among students are influenced by the harmonisation of facilities, however, these interactions are vital in improving the quality of students (Cox *et al*., 2010). Studies examining student interactions at the faculty levels focused on frequency, quality and student total satisfaction (Trolian *et al.*, 2016).

The reviewed studies never considered that harmonised facilities through architectural designs could enable student interaction. In addition, architectural designs in the literature fail to consider the harmonisation of facilities in the tertiary institution. This study intends to fill the gap by proposing a design to enhance student interaction. However, assessments from existing studies show facilities need adequacy to meet current provisions and future expectations. Empirically in literature, the design phases which take cognizant of both all-encompassing architectural and educational principles are subject to ethical positions without empirical substantiation and this indicates little acknowledgement of the significance of context for each school.

Closer examinations of our educational facilities across Nigeria, with an emphasis on the faculty of Architecture, reveal that the much-desired interaction in a faculty that educates professionals is missing. Most widely used facilities are either not accessible or are not incorporated into the overall system, so these are missing. The harmonisation of these facilities would significantly reduce the cost of delivering services to individual departments. It will also assist in the development of an engaging learning atmosphere for both students and lecturers. This work aims to provide a solution to the problem

of interaction to improve student learning. There is vast gap on empirical literature on architectural space for the design of faculty facilities. The existing literature in this aspect are theoretical and lack empiricism in terms of measurement variables.

Furthermore, the faculty of Architecture is committed to the study of the natural and artificial systems primarily comprising cities, buildings and industrial products organised around two basic disciplines of design and planning. Problems ranging from the creation of industrial products and architecture to landscape and settlements system are covered in lectures, fieldwork and studios, where the aim is to bring together knowledge, methodology, theory and a high level of professional skills within the framework of projects. The issue of unbundling the Departments of Architecture in Nigerian Universities into Faculties of Architecture becomes a reality with the nod given to the project at the 2012 Architects' Colloquium. The Departments were encouraged to mount at least two programs that could metamorphose into Departments together with the existing Departments of Architecture as the third to give the minimum number of Departments required to form a Faculty.

This being a new initiative in Nigeria, there are bound to have challenges, amongst which are; physical infrastructure, equipment, laboratories and workshops, Information and Communication Technology, ICT, and Architecture as a professional program need a sustained, planned and programmed action for the revitalisation of student's interactions. This sustained process for action is not provided for now nor is any planned for. The need for harmonised facilities cannot be overemphasised. Therefore, it is pertinent to propose a design that could harmonise facilities for effective student interaction. This study will serve as a guide for architectural design for faculty buildings in tertiary institutions.

RESEARCH METHODOLGY

The research employs a mixed-methods approach to investigate the impact of architectural space on student interaction and performance. The chosen research design guides the systematic progression of stages to address research questions efficiently and accurately. Drawing from Kumar (2011), this study orchestrates circumstances for data collection and analysis, maintaining relevance to research objectives and economic feasibility. An exploratory survey design is adopted, suitable for illuminating architectural space's significance in enhancing student interactions and performance.

The study population consists of students in the architecture department at the University of Uyo, Akwa Ibom State, Nigeria. While not statistically representative of all Nigerian tertiary institutions, the shared need for faculty facilities allows potential generalization. Students are categorized as undergraduate and postgraduate, selected directly due to their involvement in architectural education and the relevance of faculty facilities.

The techniques adopted for the selection of the sample size was the Yaro's Yamane formula.

Applying the Yaro Yamane formular, given as:

$$n = \frac{N}{1 + N(e)^2} \quad \text{..... (1)}$$

Where:
n = the sample size
N = finite population
e = Level of significance (0.05)
1 = Unity
(Yamane, 1967)

Table 1: Population Size and Sample Size of the Selected Students

Students Level	Population size	Sample size
Undergraduate	334	182
Postgraduate	150	109
Total	**594**	**291**

Source: Author's Field Survey (2022).

Sampling involves random/probability techniques due to their practicality. The technique aims to represent the broader population and ensure each student's equal likelihood of selection. The process entails listing possible samples on paper slips, drawing from them to determine the sample size. In this case, 291 respondents, comprising 182 undergraduates and 109 postgraduates, were selected. The Yamane formula guided the sample size determination.

Data collection primarily employs structured questionnaires, a widely used method. The questionnaire is designed using a five-point Likert scale to gauge respondent agreement, with 1 indicating "very low" and 5 indicating "very high." Secondary data collection involves reviewing relevant literature from journals, articles, and similar sources.

Data analysis utilizes SPSS 2013, employing percentage calculations for background information and Mean Item Score (MIS) for objective-related responses. Ethical considerations are integral, with informed consent obtained from respondents, ensuring confidentiality and avoiding harm. Open and honest interactions prevent distortion of responses, maintaining data accuracy. To circumvent deception, the study transparently discloses its purpose and pertinent personal information.

DATA PRESENTATION, ANALYSIS AND DISCUSSION OF FINDINGS

Data Presentation and Analysis

The data employed to evaluate the envisioned blueprint for the faculty of architecture at the University of Uyo, with the aim of enhancing student engagement and achievement via the synchronization of facilities, was of a quantitative and ordinal nature. The dataset captures the perspectives of students within the research milieu. In the ensuing segments, the information obtained from the on-site survey is dissected and portrayed in accordance with the research objectives. The outcomes derived from the scrutiny of the data are subsequently expounded upon and deliberated to deduce their implications.

A total of 291 questionnaires were distributed to students enrolled in the architecture department of the University of Uyo, located in Akwa Ibom State, in line with the specified sample size for the investigation. Among these, 282 questionnaires were successfully retrieved and subjected to analysis due to their accurate completion. This results in a response rate of 96.9%. This response rate is deemed suitable for establishing a valid statistical sample to underpin the conclusions and findings of the study. The survey methodology employed in this study is anticipated to yield a comparable response rate in future inquiries.

Characteristics of Respondents - The backgrounds of the respondents who provided the data used in this study were scrutinized to gain insight into the perceptions of students concerning the proposed design for the faculty of architecture at the University of Uyo, with the overarching objective of enhancing student interaction and performance through the integration of facilities. The study examined five demographic factors encompassing age, gender, academic level, development of the proposed architecture faculty, and whether the existing faculty facilities contribute to enhanced interaction among the respondents. These variables serve as potential aspects (attributes) that might influence the development of the architecture faculty.

Table 2 presents the distribution of respondents across different age brackets. The majority of respondents (48%) fall within the age range of 20 to 30 years, with 33% falling between 31 and 40 years, and 19% aged 40 years and above. Gender-wise, 75% of respondents identify as male, while 25% identify as female. Moreover, 62% of the respondents are pursuing undergraduate studies, whereas 38% are engaged in postgraduate studies. Given that the study revolves around improving student interaction and performance, the focus centres on two subsets of students within the architecture department—namely, undergraduate and postgraduate students. This alignment with the study's objective, which pertains to proposing a design for the architecture faculty to enhance student interaction and performance via facility harmonization, underscores the rationale behind the chosen participant groups.

The profile of the respondents' characteristics indicates a reasonable level of expertise, lending credence to the reliance on their opinions.

Table 2: Respondents' Characteristics

Variables	Categories	Frequency	Percent (%)
Age	20- 30years	147	48%
	31 – 40years	104	33%
	Above 40years	31	19%
	Total	**282**	**100%**
Gender	Male	211	75%
	Female	71	25%
	Total	**282**	**100%**
Studentship level	Undergraduate	175	62%
	Postgraduate	107	38%
	Total	**282**	**100%**

Source: Author's Field Survey (2022).

Architectural Spaces that are unique and peculiar to the various architectural departments - The primary aims of this investigation encompassed the analysis of architectural environments requisite for devising the framework of the school of architecture. These architectural spaces were discerned through an exploration of pertinent scholarly works. A total of fourteen distinct variables were distilled from the body of literature. The findings gathered from on-site surveys were meticulously evaluated and ordered based on their average item scores. The outcomes meticulously detailed in Table 3, illuminates on the indispensable nature of students' evocative interpretations regarding pivotal spaces crucial to the conception of the faculty of architecture.

Table 3: Architectural spaces that are unique and peculiar to the various architectural departments

Spaces	Mean Item Score	Ranking	Remarks
Lecture space/hall	4.323	1st	Significant
Design studios	4.222	2nd	Significant
Seminar hall	4.111	3rd	Significant
Exhibition hall	4.111	3rd	Significant
External landscape	4.045	5th	Significant
Flexible space	4.045	5th	Significant
Office space	3.888	7th	Significant
Functional space	3.845	8th	Significant
Library space	3.777	9th	Significant
ICT space	3.634	10th	Significant
Lavatories	3.550	11th	Significant
Passage space	3.452	12th	Significant
Corridors	3.440	13th	Significant
Car park	3.320	14th	Significant

Source: Author's Field Survey (2022).

The outcomes depicted in Table 3 offer insights into the perceptions held by students across different academic levels concerning the distinct and exceptional architectural environments inherent to the layout of our architectural faculty. The intention behind these unique spaces is to enhance student engagement and performance through the integration of harmonized facilities. The findings as presented in Table 3 unveil indicators of spatial significance pivotal in the conceptualization of faculty's architectural spatial facilities. Among these, the lecture space/hall claims the top spot with a notable mean score of 4.323, followed closely by the design studios hall/space, securing the second position with a mean score of 4.222. The seminar hall and exhibition hall occupy the third rank with a mean score of 4.111.

The perceptions of the respondents illuminate that out of the 14 architectural spaces examined, a total of 11 hold paramount importance in the evolution of architecture faculty. These spaces collectively attain a mean score surpassing 3.550. The lecture hall, design studios, exhibition halls, seminar halls, external landscapes, flexible spaces, office space, functional space, library halls, ICT space, and lavatories emerge as critical components in the design fabric of our architecture faculty.

Table 3 also showcases the three least influential variables in the realm of architectural space. Passage space, corridors, and parking areas assume positions 12, 13 and 14 respectively. However, the insights extracted from Table 3 disclose the presence of two discernible bands of mean item scores: one surpassing 4.00 (ranging from 4.045 to 4.323) and the other spanning from 3.320 to 3.888. This observation implies a unanimous agreement among respondents regarding the significance of all space indicators in shaping the spatial requirements for Faculty of Architecture.

Challenges Affecting Student Interaction and Performance - The second objective of the studies sought to evaluate the challenges affecting student interaction and performance. The study extracted 18 constraints inhibiting student interaction and performance individually and collectively from the literature. The results presented in Table 4 shows the descriptive perceptions of the respondents regarding the severity of challenges affecting student interaction and performance.

This objective sought to evaluate the barriers militating students' interaction and academic performance. The study systematically identified and catalogued 18 distinct limitations that hinder both individual and group student interaction and performance. These constraints were extracted from existing scholarly sources and literature. The findings, displayed in Table 4, provides an overview of how the participants perceived the intensity of the challenges that influence student interaction and academic performance.

Table 4: Barriers Militating Student Interaction and Performance

Challenges indicators	Mean	Ranking	Remarks
Poor student interaction	4.544	1st	Significant
Lack of interest in design	4.389	2nd	Significant
Subpar quality of facilities	4.367	3rd	Significant
Insufficient facilities	4.367	3rd	Significant
Poorly harmonised facilities	4.367	3rd	Significant
Low motivation	4.206	6th	Significant
The burden of assignment/design	4.115	7th	Significant
Lack of maintenance	4.082	8th	Significant
Cognitive challenges	3.872	9th	Significant
Time management issues	3.764	10th	Significant
Poor network quality	3.683	11th	Significant
Lack technology integration	3.547	12th	Significant
Lack of familiarity among students	3.506	13th	Significant
Noisy and unfriendly environment	3.456	14th	Significant
Poor learning approach	3.396	15th	Significant
Language barriers	3.375	16th	Significant
Delay in feedback	3.232	17th	Significant
Quality assurance concern	3.054	18th	Significant

Source: Author's Field Survey (2022).

The assessment of participants' rankings concerning factors that impede student interaction and performance highlights that the mean scores exceed 3.00 (specifically ranging from 3.00 to 4.544). This accounts for the entirety of the 18 constraints that were scrutinized within the scope of this study. In sum, the impact of these factors on student interaction and performance is substantial, encompassing the entirety of the factors examined. Particularly, issues related to deficient student interaction and a lack of enthusiasm for design have emerged as the most prominent obstacles, as indicated by the data (see Table 4). Consequently, it can be inferred that all 18 challenges play a pivotal role in evaluating student interaction and performance within the study's geographical context. Among these challenges, the five most influential ones encompass poor student interaction, a lack of interest in design, subpar

quality of facilities, insufficient facilities, and poorly harmonised resources. Conversely, challenges of lesser significance, such as language barriers, delayed feedback, and concerns about quality assurance, occupy the 16th to 18th positions in the ranking.

Discussion of Findings/Results

Furthermore, this study explores an in-depth synthesis of the results of data analyses presented earlier to infer their statistical, theoretical and practical implication based on the respective objectives evaluated as seen in the following sections.

Architectural Spaces that are unique and peculiar to the various architectural departments - The study shows students are knowledgeable in terms of architectural spaces needed to enhance student interactions and these architectural spaces transform to achieve and improve student performance. The collective learning processes of the student are tied to these architectural spaces and it shows that these architectural spaces are significant (mean score from 3.320 to 4.323). The top five spaces efficient in enhancing student interaction and performance include the lecture hall, design studios, seminar hall, exhibition hall, and external landscape. Others are flexible space, office space, functional space and library space. The finding of the study also shows all space indicators are significant, however, every architectural space in the study is connected to other spaces and makes the whole faculty intelligible (Savanjala, 2010; Lekjep, 2017).

The taxonomy of these architectural spaces validated in this study has both functional and flexible components (Fisher, 2005; Kariippanon *et al.*, 2019). Architectural space enhances learning by providing a learning space that mediates the nexus between social practices of teaching and learning, these multifaceted relationships of teaching notify learning outcomes (Oblinger, 2006). The finding of the study is in line with the finding of Lekjep (2017), architectural space is determined by student activity within a given space and faculty spaces about this research constitute the following spaces: design studios, lecture halls, exhibition rooms, offices, toilets, seminar hall, library, ICT hall, car parks, and external landscape among others.

Challenges Affecting Student Interaction and Performance - The results of the study reveal poor student interaction, lack of interest in design, poor quality, inadequate facilities, and poorly harmonise facilities are critical factors affecting student interaction and performance. From these results, the study infers that student interaction and performance can be strengthened by improving student interaction, increasing interest in design, enhancing technology adoption, and providing adequate facilities as well as harmonising facilities.

This finding of the study is in line with the finding of George and Walker (2017), who posited poor interaction poses a threat to student interaction. Although student interaction is positively influenced by harmonised facilities, this also implies that facilities that do not harmonise negatively affect student interaction. Olufemi *et al.* (2018) suggested that faculty facilities should be harmonised, as lack or inadequate facilities hinder student interaction. The finding of the study corroborated the finding of Islam and Sanzida (2021) posited that lack of interest in design courses or low participation in design affects student interaction.

SUMMARY, CONCLUSION AND RECOMMENDATIONS

Summary

In summary, the finding of the study shows that students are conversant in terms of architectural spaces needed to enhance student interactions and these architectural spaces transform to achieve and improve student performance. The collective learning processes of the student are tied to these architectural spaces and it shows that these architectural spaces are significant (mean score from 3.320 to 4.323). The top three spaces that are vital to architecture students are the lecture halls with a mean score of 4.323, the design studios hall/space with a mean score of 4.222, seminar and exhibition hall with a mean score of 4.111.

Poor student interaction, lack of interest in design, poor quality, inadequate facilities, poorly harmonise facilities, low motivation, the burden of assignment/design, lack of maintenance, cognitive challenges, time management issues, poor network quality, lack of technology integration, lack of

familiarity are critical challenges affecting student interaction and performance with a mean score above 3.500. However, the archetype of principal constraints influencing student interaction and performance are poor student interaction, lack of interest in design, poor quality, and inadequate facilities and poorly harmonise facilities.

However, student satisfaction can be measured mainly from the perspective of water and power supply, trust and commitment, and effective collaboration among staff and students. Sustainable practice. Interestingly, tertiary institutions are deemed to prioritise. Overall, students adjudged that the existing facility does not meet their satisfaction.

Conclusion

Space has emerged as one of the most important concepts in developing faculty facilities. Amidst this growing attention, existing research engagements focused on space and applications across the development of faculty facilities to the neglect of architectural space and its roles in enhancing student interaction and performance. However, assessments from existing studies show facilities need adequacy to meet current provisions and future expectations. The major goal of the tertiary institution is to provide adequate interaction among students proficient in obtaining skills need to exploit natural resources that make it imperative for facilities to be excessively accessible in tertiary institutions. Faculty of architecture required of management of tertiary institutions embodies exhibition halls, seminar halls, design studios and lecture halls. This means students in the department or faculty of architecture are expected to produce efficiency in transforming knowledge related to interactions and performance. These sets of architectural spaces are objectives to produce efficiency in transforming proficiently student interaction and performance through harmonised facilities. This finding implies that, if stakeholders and tertiary institutions do not integrate the identified architectural spaces during the design phase, the overall performance of students may be jeopardized.

Overall, students adjudged that the existing facility does not meet their satisfaction. in addition, students are not satisfied in terms of water and power supply, trust and commitment, and collaboration among staffs and students. This finding implies that tertiary institution delivering service must ensure their service satisfy students. On the other hand, poor student interaction, lack of interest in design, poor quality, inadequate facilities and poorly harmonise facilities are critical challenges affecting student interaction and performance. Based on these results, the study concluded that the faculty facilities need to be harmonised to enhance student interaction and performance. The finding further implies that if tertiary institutions do not prioritise their architectural space, then students won't be satisfied with the service delivered and may suffer poor interaction and performance as noted in the literature.

Environmental Implications of Findings

The findings of this study are important to the development of policy, practice and subsequent research. The study contributes to the body of knowledge on the development of tertiary institutions on which future or further research can be conducted and also expand the current knowledge base. The findings of this study will reshape research carried out on the design and construction of faculty facilities in Nigeria. This study opens up areas for further research theories; methodology and even conceptual frameworks can be developed.

Furthermore, the interaction between students will go a long way to achieve a sense of harmony and unity in faculty facilities. Thus, an architecture of flexible spaces as they relate to the design education by creating workable (useable) spaces through the integration of the various and distinct design activities in a learning environment. The role of this built environment (architecture) allows an integration of design education to take place in a stimulating and environment responsive structure. Thus an overall and important role of the environmental designer which is not only the shaping and moulding of the natural environment as well as its management but the shaping of the immediate surrounding and thereby, achieving the ultimate goal of creating a better society and environment for all.

The findings of this study will influence design and construction practice, as spaces provided for faculty facilities will be influenced to ensure the harmonisation of faculty facilities towards student interaction and performance. In developing policies in a tertiary institution for developing newer faculty

facilities, this study should be considered as a decision tool. The study will influence design and construction practice, professionals and stakeholders as a properly harmonise faculty facility enhances student interaction and performance.

Architectural spaces that are properly harmonised will have an impact on the school environment as it will change student behaviour and interaction which could better their performance. The finding of this study shows the usefulness of properly harmonising faculty facilities, and how it will influence student performance.

The study advances some useful theoretical insights which show that architectural spaces that are properly harmonised are predicated on the impact on student interaction and performances. The study showed that challenges affecting student interaction and performance and student satisfaction that both dimensions are interdependent. In expounding the phenomenon of place theory, the study verified the theoretic underpinning of the relationship between place and space in the design of faculty facilities. The study adds dimensions for improving practical evaluation and theoretical conceptualisation of student satisfaction.

Recommendations

The study's recommendations for enhancing student interaction and performance within faculty facilities are summarized as follows:

1. Tertiary institutions should optimize architectural spaces, particularly areas with high levels of harmonization like exhibition halls, seminar halls/spaces, design studios, and lecture hall groupings, to sustain and further improve student interaction and performance.
2. To reinforce student interaction and performance, institutions should focus on improving student satisfaction. Key areas requiring attention include ensuring easy access to studios, well-maintained restroom facilities, quality design outcomes, enhanced security measures, comfortable lecture halls, well-equipped libraries, reliable internet services, overall facility quality, adequate parking spaces, and clearly marked escape routes.
3. Stakeholders involved in facility design and construction should prioritize the integration of the identified architectural spaces, as these spaces serve as the most effective path towards creating harmonized faculty facilities.
4. Collaboration between tertiary institutions, stakeholders in the built environment, and government is essential. This collaboration should establish a strategic roadmap aimed at enhancing student interaction and performance within faculty facilities across Nigeria.
5. Institutional management should prioritize the improvement of facilities that have received low levels of student satisfaction, addressing their shortcomings to better support interaction and performance.
6. Universities should regularly seek feedback from students regarding their satisfaction with facilities. This feedback can serve as valuable input for prioritizing improvements and enhancing the overall student experience.
7. Government should allocate and disburse sufficient funds to tertiary institutions, demonstrating a strong commitment to higher education. Adequate funding will enable proper management of affairs and contribute to improved functionality, interaction, and performance within faculty facilities.

REFERENCES

Akhihiero, E. T. (2011). Effect of Inadequate Infrastructural Facilities on Academic Performance of Students of Oredo Local Government Area of Edo State. *The Nigerian Academic Forum*, 20(1): 1-6.

Alnusairat, S., Al Maani, D. and Al-Jokhadar, A. (2020). Architecture students' satisfaction with and perceptions of online design studios during COVID-19 lockdown: the case of Jordan universities. *International Journal of Architectural Research Archnet-IJAR*, 15(1): 219-236.

Alnusairat, S., Al-Shatnawi, Z. and Kakani, A. (2020). Towards an integrated sustainable university campus: the social pillar - case of Al-Ahliyya Amman University in Jordan. Paper presented at PLEA-2020 Conference: Planning Post Carbon Cities, Spain, 1-3 Spectember, CORUNA University.

Arisi, R. O. (2002). The universal basic education: problems and prospects. Refocusing education in Nigeria (eds.: Oriaifo, S. O., Nwaokolo, P. O. E. and Igbogbor, G. C.), Benin City: Da-Sylva Influence, 306-310.

Asaju, K. and Adagba, S. O. (2014). Functional Education in Nigeria: A Catalyst for Effective Poverty Alleviation. *Research Journal in Organizational Psychology and Educational Studies*, 3(4):313-318.

Asiyai, R. I. and Okoro, P. (2019). Management Strategies for Improving the Functionality of Tertiary Education in Nigeria. *International Journal of Higher Education*, 8(4): 108-114.

Azeiteiro, U.M., Bacelar-Nicolau, P., Caetano, F.J.P. and Caeiro, S. (2015). Education for sustainable development through e-learning in higher education: experiences from Portugal. *Journal of Cleaner Production*, 106(1): 308-319.

Banfegha, N. V. (2014). Harmonisation of the Educational Sub-Systems of Cameroon: A Multicultural Perspective for Democratic Education. *Creative Education*, 5: 334-346.

Blackmore, J. and Kamp, A. (2008). Education as a determinant of health and wellbeing, in Keleher, H. and MacDougall, C. (eds), Understanding health: a determinants approach, pp. 218-228, Oxford University Press, South Melbourne, Vic.

Blaxter, L., Huges, C., and Tight, M. (2001). *How to research.* 2nd Edition, Open University Press, London, UK, 2001.

Bowen, G. L., Rose, R. A., Powers, J. D. and Glennie, E. J. (2008). The joint effects of neighborhoods, schools, peers, and families on changes in the school success of middle school students. *Family Relations*, 57(4): 504-516.

Casanova, D. and Price, L. (2018). Moving towards sustainable policy and practice – a five level framework for online learning sustainability. *Canadian Journal of Learning and Technology*, 44(3): 1-20.

Charles, K. E., Danforth, A. J., Veitch, J. A., Zwierzchowski, C., Johnson, B. and Pero, K. (2004). Workstation Design for Organizational Productivity: Practical advice based on scientific research findings for the design and management of open plan offices. Retrieved from http://irc.nrccnrc.gc.ca/ie/productivity/index on 24th October 2014.

Cho, M. and Auger, G. A. (2013). Exploring determinants of relationship quality between students and their academic department: Perceived relationship investment, student empowerment, and student–faculty interaction. *Journalism and Mass Communication Educator*, 68: 266-268.

Cox, B. E., McIntosh, K. L., Terenzini, P. T., Reason, R. D., and Lutov sky Quaye, B. R. (2010). Pedagogical signals of faculty approach abil ity: Factors shaping faculty–student interaction outside the classroom. *Research in Higher Education*, 51: 767-788.

Eduwen, F. O. and Osagie-Obazee, G. E. (2016). Teacher Education: A Panacea for National Development in Nigeria. *African Research Review: An International Multi-Disciplinary Journal*, 10(4): 106-114.

Filardo, M. (2008). Good buildings better schools: An economic stimulus opportunity with long-term benefits, EPI Briefing Paper 216, Economic Policy Institute, Washington D.C. Available at: http://www.sharedprosperity.org/bp216.html

Fook, C. Y. and Sidhu, G. K. (2015). Investigating Learning Challenges faced by Students in Higher Education. 5th World Conference on Learning, Teaching and Educational Leadership. *Procedia - Social and Behavioral Sciences*, 186: 604–612.

George, B.H. and Walker, A. (2017), "Social learning in a distributed environment: lessons learned from online design education", in Orey, M. and Branch, R.M. (Eds), Educational Media and Technology Yearbook, Vol. 40, pp. 3-14, Springer International Publishing.

Hattie, J. (2009). *Visible learning: A synthesis of over 800 meta-analyses relating to achievement*. Routledge, London.

Islam, A. and Sanzida, T. (2021). An Analysis of Factors Influencing Academic Performance of Undergraduate Students: A Case Study of Rabindra University, Bangladesh (RUB). *Shanlax International Journal of Education*, 9(3): 127-135

Karns, G. L. (2006). Learning style differences in the perceived effectiveness of learning activities. *Journal of marketing education*, 28(1): 56-63.

Kumar, R. (2011). Research Methodology a Step-By-Step Guide for Beginners, 3rd Edition. SAGE Publications, 321p.

Lawson, B. (2001). The language of space. Oxford, UK: Architectural Press.

Lefebvre, H. (1991). The Production of Space. Oxford: Basil Blackwell. In Forty, A. (2000) Wordsand Buildings: A Vocabulary of Modern Architecture. London: Thames and Hudson.

Lekjep, R. S. (2017). User Satisfaction with Architectural Design of Spaces in Residential Buildings: Insights from Low-Cost Housing in Plateau State, Nigeria. A Ph. D Work submitted to the Department of Architecture, University of Jos.

Massey, D. (1994). Place, space and gender, Polity Press, Cambridge.

Mulford, B. (2005). Quality evidence about leadership for organizational and student learning in schools. *School Leadership and Management*, 25(4): 321-330.

Oblinger, D. G. (2006). Learning spaces. Educause, Boulder. Available at: http://www.educause.edu/LearningSpaces.

Ogbu, C. P. and Imafido, M. O. (2020). Criteria for selection of consultants for tertiary institution construction projects in Nigeria. *The Quantity Surveyor*, 66: 68-81.

Olufemi, O. T., Adediran, A. A. and Oyediran, W. O. (2018). Factors Affecting Students' Academic Performance in Colleges of Education in Southwest, Nigeria. *British Journal of Education*, 6(10): 43-56.

Oluwunmi, A. O., Ajibola, M. O., Iroham, C. O. and Eluyele, P. (2017). Students' Satisfaction with Major Academic Facilities in Private Universities in Ogun State, Nigeria. *Covenant Journal of Business and Social Sciences*, 8(1): 43-59.

Onyali, L. C. and Nnebedum, C. (2021). Determination of Internal Efficiency rate of undergraduate Programme in Public Universities in Anambra State, Nigeria. *International Journal of all Research Education and Scientific Methods*, 9(8): 1813-1821.

Ready, D., Lee, V. and Welner, K. (2004). Educational equity and school structure: School size, overcrowding, and schools-within-schools. *The Teachers College Record*, 106(10): 1989-2014.

Savanjala, R. (2010). Relationship in architectural Space: Design and effect in space of the Traditional Thai houses and temples: The Bartlett. London: University College.

Tan, C. K. and Yeoh, K. C. (2011). A Study on the Use of Measurement Software in the Preparation of Bills of Quantities Among Malaysian Quantity Surveying Firms. In the 9th International Conference on ICT and Knowledge Engineering, 12-13 January, Bangkok, Thailand.

Tanner, C. K. (2009). Effects of school design on student outcomes. *Journal of Educational Administration*, 47(3): 381-399.

Tatum, H. E., Schwartz, B. M., Schimmoeller, P. A., and Perry, N. (2013). Classroom participation and student–faculty interactions: Does gender matter? *Journal of Higher Education*, 84: 745-768.

Trolian, T. L., Jach, E. A., Hanson, J. M. and Pascarella, E. T. (2016). Influencing Academic Motivation: The Effects of Student–Faculty Interaction. *Journal of College Student Development*, 57(7): 810-826.

Umbach, P. D., and Wawrzynski, M. R. (2005). Faculty do matter: The role of college faculty in student learning and engagement. *Research in Higher Education*, 46: 153-184.

Woldegiyorgi, A. A. (2018). Harmonisation of higher education in Africa and Europe: Policy convergence at supranational level. *Tuning Journal for Higher Education*, 5(2): 133-157.

Journal of the Faculty of Environmental Studies, University of Uyo, JED, Vol. 18 N0. 2, August, 2023

TABLE OF CONTENTS

ISSN: 1595-9229-15