SCHOOL OF ENVIRONMENTAL TECHNOLOGY, FEDERAL UNIVERSITY OF TECHNOLOGY
MINNA, NIGER STATE, NIGERIA

4th INTERNATIONAL CONFERENCE (SETIC2022)

BOOK OF PROCEEDINGS

MAIN THEME:

SUSTAINABLE DEVELOPMENT AND RESILIENCE OF THE BUILT ENVIRONMENT IN THE ERA OF PANDEMIC

6th - 8th February, 2023

VENUE: NITDA Centre, Federal University of Technology, Minna, Niger State, Nigeria

Chief Host
Prof. Faruk Adamu Kuta
Vice-Chancellor
Federal University of Technology Minna, Nigeria

Host
Prof: R.E. Olagunju mnia
Dean, School of Environmental Technology
Federal University of Technology Minna, Nigeria

EDITOR IN CHIEF
B.J. Olawuyi

Stellenbosch University Iyunivesithi Universiteit

Namibia University of Science and Technology

Massey University Te Kunenga ki Pūrehuroa University of New Zealand

جامعة نجران
NAJRAN UNIVERSITY

GSF

School of Environmental Technology International Conference (SETIC 2022)

6th – 8th Februay, 2023

Federal University of Technology Minna, Niger State, Nigeria

BOOK OF PROCEEDINGS

EDITOR IN CHIEF
B. J. Olawuyi

ISBN 978-978-54580-8-4

Proceedings of the 4th School of Environmental Technology International Conference (SETIC 2022)

Published by
School of Environmental Technology,
Federal University of Technology Minna.
PMB 65, Minna,
Niger State Nigeria.

© School of Environmental Technology, Federal University of Technology Minna 2023

ISBN 978-978-54580-8-4

Editor-in-chief:	Dr. Olawuyi, Babatunde James	Federal University of Technology Minna. Niger State, Nigeria
Editors:	Dr. Ogunbode, Ezekiel Babatunde	Federal University of Technology Minna. Niger State, Nigeria
	Surv. Adesina, Ekundayo A	Federal University of Technology Minna. Niger State, Nigeria
	Dr. Sule, Abass Iyanda	Federal University of Technology Minna. Niger State, Nigeria
	Dr. Ajayi Oluibukun Gbenga.	Namibia University of Science and Technlogy, Namibia
	Dr, Akande Olufemi K.	Department of Architecture, Federal University of Technology, Minna
	Mr. Morenikeji, Gbenga	Federal University of Technology Minna. Niger State, Nigeria
	Mr. Akande, Olaide S.	Department of Urban and Regional Planning, Federal University of Technology, Minna
	Mrs. Odine, Linda	Department of Quantity Surveying, Federal University of Technology, Minna
	Prof. James O.B. Rotimi	Massey University New Zealand
	Asst. Prof. Dodo Yakubu Aminu	Architectural Engineering Department, College of Engineering, Najran University, Najran, 66426, Kingdom of Saudi Arabia
	Dr. Renuka Thakore	Founder, Institute for Global Sustainable Futures, Progress through Partnership, UK

No responsibility is assumed by the Publisher for any injury and/or any damage to persons or properties as a matter of products liability, negligence or otherwise, or from any use or operation of any method, product, instruction, or idea contained in the material herein.

Copyright © 2023 by School of Environmental Technology, Federal University of Technology Minna, Nigeria. All rights reserved.
This publication is protected by Copyright and permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise.

PREFACE

The 4th edition of School of Environmental Technology International Conference (SETIC2022) is organised by School of Environmental Technology, Federal University of Technology Minna, Nigeria. In collaboration with Massey University New Zealand, University of Namibia, Namibia, Department of Architectural Technology, Najran University, Saudi Arabia, Deapartment of Civil Engineering, Stellenbosch University, Stellenbosch, South Africa and the Global Sustainable Futures, UK.

The main theme for this year conference is "**Sustainable Development and Resilience of the Built Environment in the Era of Pandemic**" and is of interest to everyone going by the fact that housing is a necessity following only after food and clothing while living in crowded places and poor sanitation is a concern and possible cause of spread of diseases and occurrence of epidemic/pandemic. This promotes and encourage innovative and novelty for emerging property management strategies in a pandemic era; modern geospatial tools for epidemiology; architecture, resilience and healthy buildings in pandemic era; planning for sustainable resilient neighbourhoods and cities in COVID-19 era; sustainable and resilient cities; sustainable cost management of built environment projects in the era of covid-19; wellbeing and resilience of the built environment.

The responses from participants for this conference are overwhelming, well attended, and successful. The operation mode was virtual for all participants with presentations in mode Our participants are from various Universities and other sector across the globe, from countries like United Kingdom, New Zealand, Saudi Arabia, South Africa, Namibia, Ethiopia and Nigeria just to mention a few. Hence, this conference provides a good platform for professionals, academicians and researchers to widen their knowledge and approach on latest advances in research and innovation. Papers presented in this conference cover a wide spectrum of science, engineering and social sciences.

Finally, a note of thanks must go to SETIC 2022 Local Organizing Committee (LOC) for their remarkable dedication in making this conference a success. We hope the event will prove to be an inspiring experience to all committee members and participants.

ACKNOWLEDGEMENTS

The effort put together in achieving the success of SETIC 2022 is predicated on the feat of the previous three edition of School of Environmental Technology International Conference held in 2016, 2018 and 2021, respectively. The support and goodwill from Vice-Chancellor of Federal University of Technology, Dean School of Environmental Technology, Dr. Renuka Thakore, Dr Dodo Y. A., Prof. James O.B. Rotimi and many other highly motivated people are highly appreciated.
It is also my privilege and honour to welcome you all, on behalf of the Local Organizing Committee (LOC) to the 4^{th} edition of the Biennial School of Environmental International Conference (SETIC2022). This Conference which was earlier schedule for April, 2022 is holding now (6^{th} to 8^{th} th February, 2023) due to the prolonged ASUU-FGN crisis which made our public Universities in Nigeria to be closed for over Eight Months. Our experience in the 3^{rd} edition held in 2021 after the COVID-19 Pandemic has thought us on new ways of doing things with the Virtual Conferencing offering us a wider coverage, it is our hope that SETIC2022 will be an improvement on the Participants experience of opportunity available for global networking and interaction at Conferences via the Virtual mode of presentation.

The conference provides an international forum for researchers and professionals in the built environment and allied professions to address fundamental problems, challenges and prospects of **Sustainable Development and Resilience of the Built Environment in the Era of Pandemic**. The conference is a platform where recognized best practices, theories and concepts are shared and discussed amongst academics, practitioners and researchers. This 2022 edition of SETIC has listed in the program a Round Table Talk on on Housing Affordability Beyond COVID-19 with selected Speakers from across the globe available to do justice on the topic of discussion. Distinguished Conference participants, permit me to warmly welcome our Keynote:

- Dr. Ibrahim Idris, *Director Public health, State Ministry of Health, Niger State, Nigeria;*
- Dr. A.A. Bilau, *Lecturer and expert in Disaster Risk Management, Department of Building, Federal University of Technology, Minna, Nigeria and;*
- Dr. Yakubu Aminu Dodo, *Ass. Prof. Architecture Engineering Department, Faculty of Engineering, Najran University, Najran, Saudi Arabia;*

And the lead Discussants for the Round Table Talk:

- Prof. James O.B. Rotimi, *Professor of Construction Economics & Management, School of Built Environment, College of Sciences, Massey University of New Zealand;*
- Prof. O.A. Kemiki, *Professor of Estate Management and Valuation, Federal University of Technology, Minna, Nigeria;*
- Dr. Renuka Thakore, *Founder, Institute for Global Sustainable Futures, Progress through Partnership, UK;*
- Dr. Guillermo Delgado, *Senior Lecturer, Architecture and Acting Director, Institute of Land, Livelihoods and Housing (ILlH), Namibia University of Science and Technology, Namibia;*
- Prof. Adewumi John Babafemi, *Associate Professor and Head of Construction Materials and Unit; Stellenbosch University, Stellenbosch, South Africa*;
- Dr. Yakubu Aminu Dodo, *Ass. Prof. Architecture Engineering Department, Faculty of Engineering, Najran University, Najran, Saudi Arabia.*

for accepting to share from their knowledge, wealth of experience and be available to interact with participants on varied issues on "**Sustainable Development and Resilience of the Built Environment in the Era of Pandemic**".
As reflected on the Conference program, the Conference activities will be Virtual for all presenters to run in four parallel sessions on the Zoon platform. With a total of Seventy (70) articles captured in the Conference Proceedings covering the six subthemes of the Conference, I have no doubt that we are all in for an impactful experience at SETIC2022 as we brainstorm, exchange ideas, share knowledge and participate in evolving more approach to sustainable housing and land management drives.

I implore us all to enjoy every moment of the deliberations and ensure we maximize the great opportunity offered by the Conference to network for better research and career development as we also make new friends.

I also on behalf of myself and the LOC express our appreciation to the Dean, School of Environmental Technology and the entire Staff of the School for giving us the opportunity to steer the ship for SETIC2022. To the Reviewers and various Committees that served with us, I say thank you for helping us through despite the pressure of work.

Thanks, and God bless you all.

Olawuyi, B.J. (PhD)
Chairman, LOC
SETIC2022

COPYRIGHT STATEMENT

© Copyright. School of Environment International Conference (SETIC2022). The copyright for papers published in the SETIC Conference Proceedings belongs to authors of the papers.

Authors are allowed to reproduce and distribute the exact format of papers published in the SETIC2022 Conference Proceedings for personal and educational purposes without written permission but with a citation to this source. No unauthorized reproduction or distribution, in whole or in part, of work published in the SETIC2022 Conference Proceedings by persons other than authors is allowed without the written permission of authors or organizers of the SETIC2022 Conference.

We have taken all necessary cautions to comply with copyright obligations. We make no warranties or representations that material contained in the papers written by authors do not infringe the intellectual property rights of any person anywhere in the world. We do not encourage, support or permit infringement of copyrights / intellectual property rights by authors. Should you consider any violation of your copyrights please do not hesitate to contact the conference secretariat at setic@futminna.edu.ng

SETIC2022 accepts no liability for copyright infringements or inappropriate use of material in any paper published. All authors developed their papers in line with the guiding principles of academic freedom and are responsible for good academic practice when conducting and reporting scientific research.

Correspondence relating to copyrights and requests for permission to use material from the SETIC2022 Conference Proceedings should be made to: Secretariat of SETIC Conference email: setic@futminna.edu.ng

DECLARATION

PEER REVIEW AND SCIENTIFIC PUBLISHING POLICY STATEMENT

6^{th} February, 2023

TO WHOM IT MAY CONCERN

I wish to state that all the papers published in SETIC2022 Conference Proceedings have passed through the peer review process which involved an initial review of abstracts, review of full papers by minimum of two referees, forwarding of reviewers' comments to authors, submission of revised papers by authors and subsequent evaluation of submitted papers by the Scientific Committee to determine content quality.

It is the policy of the School of Environmental Technology International Conference (SETIC) that for papers to be accepted for inclusion in the conference proceedings it must have undergone the review process and passed the academic integrity test. All papers are only published based on the recommendation of the Reviewers and the Scientific Committee of SETIC

Babatunde James OLAWUYI
Chairman SETIC2022
Federal University of Technology, Minna, Nigeria

Papers in the SETIC2022 Conference Proceedings are published on www.futminna.edu.ng, AND ALSO SELECTED PAPERS WILL BE PUBLISHED IN REPUTABLE JOURNALS

ORGANISING COMMITTEE

CHIEF HOST

Prof. Faruq Adamu Kuta
Vice-Chancellor,
Federal University of Technology Minna, Nigeria

HOST

Prof. Olagunju Remi Ebenezer
Dean
School of Environmental Technology,
Federal University of Technology Minna, Nigeria

CONFERENCE CHAIRS

Conference Chair	Parallel Sessions
Prof. Nuhu, M.B.	Emerging Property Management Strategies in a Pandemic Era
Prof. Junaid, A	Planning for Sustainable Resilient Neighbourhoods and Cities in Pandemic Era
Dr. Opaluwa, Y.D.	Modern Geospatial Tools for Epidemiology
Dr. Anifowose, M. O.	Sustainable Cost Management of the Built Environment Projects in the Era of Pandemic
Dr. Olatomiwa, Lanre	Wellbeing and Resilience of the Built Environment
Prof. Ayuba, P.	Architeture, Resilience and Healthy Buildings in Pandemic Era

CONFERENCE ADVISORY COMMITTEE

Dr. Isah, A. D	HOD, Department of Architecture
Dr., Apeh, J. A.	HOD, Department of Building
Dr. Popoola, N. I	HOD, Department of Estate Management and Valuation
Dr. Mohammed Y.	HOD, Department of Quantity Surveying
Prof. Musa A.	HOD, Department of Surveying and Geoinformatics
Dr. Bala Banki	HOD, Department of Urban and Regional planning

LOCAL ORGANIZING COMMITTEE

Dr. Olawuyi B. J.	Chairman	Department of Building, Federal University of Technology Minna, Nigeria
Surv. Adesina E. A.	Secretary	Department of Surveying and Geoinformatics, Federal University of Technology Minna, Nigeria
Dr. Muhammad I.B.	Member	Deputy Dean, School of Environmental Technology, Federal University of Technology, Minna
Dr. Ogunbode E. B.	Member	Department of Building, Federal University of Technology Minna, Nigeria
Dr. Sule A. I.	Member	Department of Estate Management and Valuation, Federal University of Technology Minna, Nigeria
Dr. Ajayi O. G.	Member	Namibia University of Science and Technology, Namibia
Mr. Morenikeji G.	Member	Department of Estate Management and Valuation, Federal University of Technology Minna, Nigeria
Mrs. Odine L.	Member	Department of Quantity Surveying, Federal University of Technology Minna, Nigeria
Mr. Akande O. S	Member	Urban and Regional planning, Federal University of Technology Minna, Nigeria
Dr. Akande O. K	Member	Department of Architecture, Federal University of Technology Minna, Nigeria
Dr. Saidu I.	Member	Department of Quantity Surveying, Federal University of Technology Minna, Nigeria

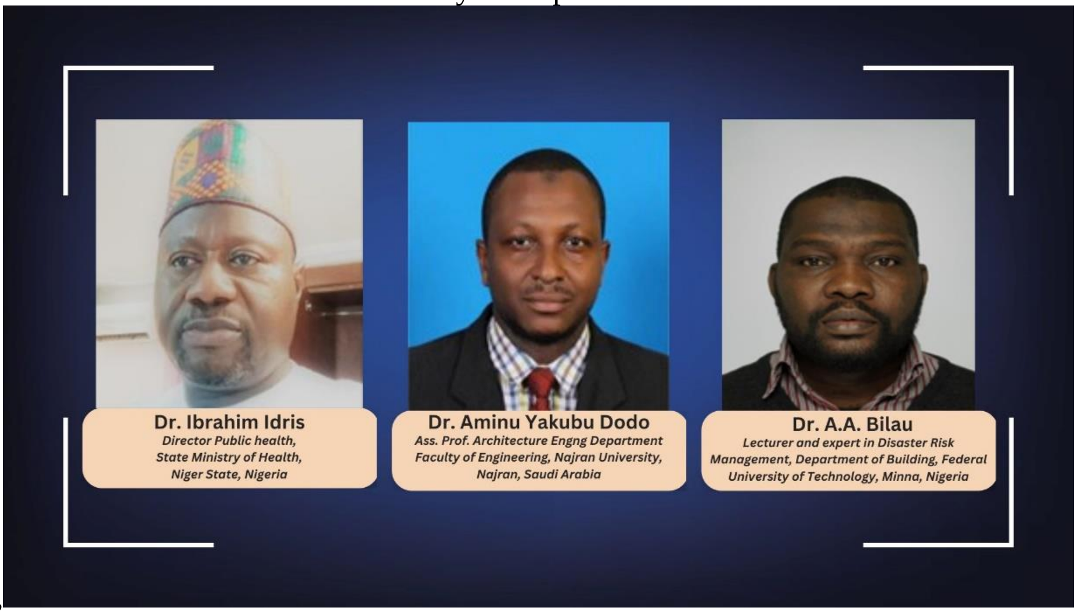
SCIENTIFIC COMMITTEE

Prof. Jimoh R.A..	Chairman	Department of Building, Federal University of Technology Minna, Nigeria
Dr Opaluwa Y.D.	Member	Department of Surveying and Geoinformatics, Federal University of Technology Minna, Nigeria
Dr. Musa D. Haruna	Member	Urban and Regional planning, Federal University of Technology Minna, Nigeria
Dr. Udoekanem N. B.	Member	Deparment of Estate Management and Valuation, Federal University of Technology Minna, Nigeria
Dr. Lawal L.A.	Member	Department of Architecture, Federal University of Technology
Miss Nmadu H.	Member	Department of Building, Federal University of Technology Minna, Nigeria
Miss. Hassan K.M.	Member	Department of Quantity Surveying, Federal University of Technology Minna, Nigeria
Mr. Kuma S. S.	Secretary	Department of Estate Management and Valuation, Federal University of Technology Minna, Nigeria

Acknowledgement To Keynote Speakers and Lead Discussants

SETIC 2022 organisers wishes to thank our keynote speakers, and Guest speakers for accepting to create time to share from their rich wealth of knowledge and interact with delegates and participants on varied issues being examined at this year's conference. A brief profile of each keynote speaker is provided here, this would allow for future interaction and networking with them.

Keynote Speakers



,

Roundtable Talk Lead Discussants

SUB-THEME 1:
EMERGING PROPERTY MANAGEMENT STRATEGIES IN A PANDEMIC ERA

Property Management Strategies in the Post COVID 19 Pandemic Era in Nigeria: Moving Beyond the Myths and Misconceptions

Ankeli, A.I.[1]; Salihu, N.[2]; Nuhu, M.B. [3a]; Sule, A.I.[3b]; Tinufa, A.A.[4]
[1]Department of Estate Management and Valuation, Federal Polytechnic, Ede, Nigeria
[2]Department of Estate Management, Bayero University, Kano, Nigeria
[3]Department of Estate Management and Valuation, Federal University of Technology, Minna, Nigeria
[4]Department of Estate Management and Valuation, Federal Polytechnic, Idah, Nigeria
[1]thonyankeli@gmail.com; [2]nasirusalihu44@gmail.com; [a]mbnuhu@futminna.edu.ng; [b]suleabbass76@futminna.edu.ng
Corresponding email: thonyankeli@gmail.com

Abstract:
The paper focuses on the dynamics of real property management strategies adopted by Property Managers (PM) in the post Covid-19 pandemic era in Nigeria. The outbreak of the pandemic has put more pressure on the Nigeria real estate market, especially the Osogbo rental market, which is currently pigeonholed with an array of management crises. The persistent and disturbing setback caused by this action has necessitated the call for urgent and immediate attention and the need to re-evaluate the current property management strategies in Osogbo. Quantitative survey data was collected through the administration of questionnaire on the respondents. This was analysed using descriptive statistical tools. Findings of the study revealed the myth and misconceptions attached to real estate agency practice by tenants. Moreso, there reported cases of hostile relationship between property owners and tenants occasioned by the misconception, the aftermath effect of covid 19 pandemic and the growing cases of rent arrears as the conventional strategies could no longer address the contemporary issues in the post pandemic era. Therefore, the paper recommended the need for aggressive public enlightenment campaign that could help transform tenants' psych/perceptions on the functions of PM, the supplying of more housing units to the housing market through public private partnership efforts and the domestication of basic health guidelines in property management plans, to promote healthy living and situations where landlords and tenants will interact as partners in progress that could engender sustainable rental growth and city development.

Keywords: *Property, Property Management Strategies, Post-Pandemic Era, Myths, Misconception.*

INTRODUCTION

The traditional perception of the role of Property Managers (PM) as mere rent collectors or caretaker among tenants and property owners have a multilateral effect on the real property market subsector of the national economy. The myth apart from encouraging animosity in the rental market especially between tenants and PM, is affecting the effectiveness of tenant selection, maintenance and rent collection procedures. It has also threatened the peaceful co-existence of the rental market participants and engendered the intrusion of quacks into the agency and management subsector of the rental market.

More recently, the outbreak of COVID-19 pandemic and the later discovery of the omicron variant across the globe, including Nigeria, brought confusion and challenges to the real property market, especially, the agency and management subsector of market. A major challenge of the property management subsector was the initial puzzle on how to respond to the then public health emergency and the modalities for curbing the further spread of the disease among occupants.

In the post pandemic era, particularly in Nigeria, the issue of how best to guard the health and safety of tenants and staff, balancing the investment objectives of the investors with the needs of workers have become a serious issue that property managers (PM) have to contend with in addition to the hostile business relationship existing between property owners/managers and tenants due to the long-standing myth and misconceptions on the role of PM in property agency practice. Rachel *et al.* (2021) suggested the need for property owners/PM to begin to think towards enacting or initiating plans (which could be emergency or scheduled) for business management and permanency as well as developing new strategies that could address or withstand outbreak of any serious public health challenges. Furthermore, Palm (2011) averred that, the competitive nature of the real property market had forced the real estate industries to develop more services-oriented strategies or approach towards property management exercises. However, Ankeli *et al.* (2021) had argued that the consequential impact of COVID-19 on the global economy, specifically the Nigeria real property subsector, has revealed the inadequacy of the conventional property management strategy adopted by PM in the country due to the dynamic nature of the property market and the low-level knowledgeability or understanding of the pandemic.

There have been reports of changing property use dynamics that affected property management strategies even before the pandemic as property management exercise has gone beyond the mere rent collection to other more sensitive areas of real property investment. The outbreak of the pandemic and the Omicron variant, apart from exposing the unpreparedness of the subsector, have a multiplier effect on property management tactics, amplifies conflicts in the rental market and exposes the inadequacies of the conventional management strategies. Hence, keeping up with the trending pace of the shifting dynamics in real property investment horizon, the myth and misconceptions of the role of PM in the subsector in the post covid 19 pandemic era and the need to be prepared against similar health emergency will require creativeness in real estate management strategies that will reorientate the psych of the investors and property users.

The conventional duty of a PM, particularly in Nigeria, which among others include tenant selection and placement, repairs and property maintenance, compliance with dynamic government regulations, the direct monitoring and reporting of financial and operational performance evaluation of the properties requires an extension to cover other contemporary issues as they arise. With the outbreak of Covid-19 or the 'new normal in December 2019 which was declared pandemic in 2020, other sensitive areas in property management have opened up. The role of the PM due to the 'new normal' has been extended beyond the mere rent agent to encompass adequate and proper management of the building, the tenants, security, safety and health of employees, customers/visitors to the premises. The PM is therefore to ensure that all are protected, the property is well maintained, and the aim of profit maximization is not compromised. It has become evident and expedient that to continue in the real property business or to thrive in the competitive real estate market requires the need for the development and preservation of an orientation that is in line with the contemporary occurrences within the environment become necessary.

Despite series of attempt made by the Nigeria Institutions of Estate Surveyors and Valuers (NIESV) at both states and national levels through mandatory continuous professional development and other forms of enlightenment campaigns on the strategic role of PM in real estate agency, myths and misconceptions originating from the psycho-cultural workings or incredulous assessments of property users in the property market persist. Nigeria is a nation with a large human population and huge real property investment potential and challenges (Ankeli *et al.*, 2021a). Some of the basic challenges confronting real property owners or managers are, aside from the unimaginable changes in the property market resulting in volatile rental regime, is the inability of people to at a point freely inhabit and interact with the physical spaces as it used to be due to the pandemic outbreak. The trend gradually brought down demand for spaces, with an increasing glut in the rental market, the conversions of the few available residential housing to other land uses due to financial inducement and the lack of observance of urban land use regulations resulting in the distortions of city master plans (Salihu *et al.*, 2020; Ankeli *et al.*, 2019 and Nwachukwu & Ukpabi, 2008). The myth or misapprehensions of the 'new normal' was construed to be a Chinese government ploy to subjugate the world economy. To others, it was a biological weapon against the world or an offshoot of the 5G innovation. These misconceptions prevented many Nigerians from taking adequate preventive measures, thereby slowing its mitigation and eradication processes in the country (Ankeli *et al.*, 2021b). Closely related to this is the misconception on the roles of PM who was seen as a mere caretaker and nothing more. As these delusions continue, the consequences of the pandemic on the real property subsector of the national economy have extended to the post covid 19 pandemic era. The problem has soared and became enormous and disturbing with an unprecedented crisis that require professional strategy for it to be resolved.

The failure to move beyond the myths and misconceptions of the role of PM and the pandemic in the property market is dangerous and must not be allowed to continue. The acceptance and inclusions of some of the Covid-19 protocol as part of modern life practice is cheering. The development and applications of modern strategies that are sustainable and which take care of challenging contemporary issues must be encourage as Gbadegesin (2022) argued that property management processes have moved from the archaic conventional method to more modern practices. However, to achieve this in the post pandemic era, there is the need for the examination of the preparedness of PM towards the changing role, the applicability of the transformative strategies/ innovations in the management of real properties in the post pandemic era as well as the re-evaluation of the myth on the role of PM which is no longer negotiable. Findings from research of this magnitude conducted in Osogbo, could serve as a baseline information for further future studies on property management strategy in the post pandemic era. It is on this background that, this study is considered justifiable, appropriate and timely.

It is in the light of the foregoing that the paper is set out to provide answers to the following questions: How prepared are the PM to handle property management issues in the post pandemic era? Is the current approach or strategies in use for property management in the post pandemic era adequate? How can the perception issues on the role of PM by tenants be resolved for PM and tenants to see each other as partners in progress?

LITERATURE REVIEW

The outbreak of the COVID-19 pandemic came with profound uncertainties both in the cooperate world and the private lives of individuals. Countries have reacted differently on how to curtail the issues or uncertainties raised by the pandemic. However, to solve the pandemic uncertainties, scholars across disciplines worldwide have modelled several empirical and theoretical approaches or concepts aimed at offering a permanent cure to the new normal, which have become part of our lives or succour on its effect on life endeavours. Fadare (2020) asserted that naturally, adjusting to change is usually difficult but should be taken slowly. He further stated that the pandemic had caused several sudden changes to organizational plans to survive the new normal, which caused some initial frictions in their business operations. However, Ankeli (2022), Sogbon and Olujimi (2015) had earlier argued that the complication of city management problems in Nigeria was due to change in use without recourse to relevant planning authorities. D'Ercole, (2016) reported the migration of businesses from the downtown core of Canada, thereby making the downtown business premises empty with a worrisome rising case of void or high vacancy rates. These studies have shown that, there have been property management problems even before the outbreak of the coronavirus pandemic in 2020 but none of these studies strictly addressed property management problem.

Furthermore, Akalemeaku *et al.* (2021) evaluated the strategies for property management in the pandemic era for the emerging markets to determine the possibility of digitalization of property management tasks in the country to achieve the management objectives of the property owner. However, the study concluded that the digitalization of the real estate sector might witness hindrances due to low broadband penetration and the myth or refusal of the people to accept the reality that the new change has become the new normal. The subject coverage and the blanket conclusion may not actually reflect the current trend of happenings across states or cities in Nigeria, as internet services have tremendously improved with options to choose from in many major cities in Nigeria. Also, property owners as well as users have in recent time become more aware and interested in real estate transaction than ever before. Hence, the none coverage of this aspect in the study created a knowledge gap that must be filled.

Oyedeji (2020) studied the impact of Covid-19 on Lagos property transactions, assessed the demand, supply, sales and rental market of the state property market transactions and the problems encountered in the pandemic era. It adopted a descriptive statistical tool in the analysis of the data collected. Findings from the study revealed bank related transaction problems. Since the pandemic outbreak became manifest in Nigeria in 2020 and the study was conducted in the same year, it means that, the research's period may not be enough to gather adequate data from the Lagos property market. Data collected and used may be on the initial effect of Covid-19 or preliminary data. Again, the study did not examine the strategies for real property management in the study area as events of the post pandemic era have negated most of the study's findings; hence, the need for a more robust and specific study to fill the observed gap. Ankeli *et al.* (2021b) evaluated rental agreement contents in some selected cities in Osun, Nigeria, to determine the adequacy or otherwise of tenancy agreements in the post-covid-19 pandemic era using a questionnaire survey approach. The study, among other things, revealed a steady dwindling rental market transaction with a deteriorating landlord/tenant relationship. The study examined an aspect of property management; hence, the need to take a deeper assessment of the all-encompassing strategies adopted in the management of real estate by PM as the myth attached to property management and the growing misconception in the public domain on the existence of the virus by property market participants become imperative.

Knowledge Gap

The literature on the subject matter has revealed that previous studies mainly investigated the impact of Covid-19 on real property transactions and the presumed operations of PM in the pandemic era. Though very few studies have theoretically discussed issues relating to real property management strategies in the post pandemic era. Besides being theoretical, these studies' attentions were more on the presumed new strategies without quantitatively assessing the adequacy or otherwise of the conventional methods or strategies in use by the PM. More so, the studies were conducted at the onset of the pandemic; hence determining the actual effects of the pandemic on real property transactions were difficult. While appreciating the fact that the earlier researches were period bound and the emanating findings were specific, recent happenings had shown that their findings and recommendations were vague. Previous studies on rental agreement adequacy were based on a fraction/ insignificant proportion of the locality studied; thus, findings from such a study cannot be generalized to cover the whole country. Again, none of these studies considered the psycho-cultural tendencies of the market participants in the post pandemic era. A concerted effort in this direction could help debug the mindset/perceptions of the citizenry towards the role of PM in the post pandemic era. Therefore, it is necessary to contentiously identify the conventional strategies in use and the need for contemporary strategies that could take care of critical issues in the post covid 19 pandemic era.

Moving Beyond the Myths and Misconception Stance

Nations had and are still adopting and modifying processes and strategies aiming at ameliorating or supporting tenants and real property investors during and after the covid 19 era. The challenge is the determination of how these changes or modifications have so far helped in the transformations or benefit the real property market participants in the post covid 19 pandemic era. Though, the outbreak of the pandemic, came with changes that have hit harder on real property investors across the value chain and altered the traditional functions of the PM. The mitigation of health risks for tenants/customers, visitors and employees have become the latest addition to the array of functions of the PM. Operating income and rate of returns were affected with default in rent payment, delays and stoppages in construction work, agitations for concession and abatement due to the failure to meet lease obligations caused by the pandemic and void rental contracts or glut in vacancy rate.

The common misconception stance among property users in Nigeria is that, PM are mere rent collectors that often aid/influence increase in urban property rentals. In similar vein, myths and misconceptions are gradually becoming synonymous with diseases outbreak in the Nigeria. The outbreak of every disease in the country are often received with misconception. Izekor *et al.* (2020) observed that it is gradually becoming historical for myths and misconceptions on health matters in Nigeria to have connections with peoples' culture and religious beliefs. The initial flagrant refusal to use facemasks and the none acceptance of Covid-19 vaccination by some Nigerians at the onset of the pandemic, the assumptions without medical proof that the virus cannot survive under Nigeria's hot climatic condition, contributed to the myth linked to cultural and religious sentiments. The misconception that the vaccine is a ploy targeted at reducing or controlling population did not helped matter; neither did our background in the rich and edifying cultural practices as people, educational escapade or religious belief that influences our cognitive and affective reasoning system. The misconception stance has, however, been traced to the none transparency in the handling of the pandemic cases by the government (Keni *et al.*, 2020; Busari *et al.*, 2020; World Health Organization, 2020 and World Health Organization 2020a). The impact of the myths and misconceptions on the real property market subsector of the economy is enormous. Though, it may look as if the pandemic is over but its impact will forever remain. Hence, the earlier the PM adopt and display exemplary conventional management strategies, the quicker and better the likelihood for the diminishing effects of the myths and misconceptions in the property industry. More so, the adoption of digitalization and unconventional analytical property management approaches could help in moving beyond the myth and misconception in the post pandemic era; thereby, building a harmonious relationship between the PM and space users through trust-building and behavioural change.

RESEARCH METHOD

The study was conducted in the metropolitan city of Osogbo, the capital of Osun state. Osogbo has and still witnessing tremendous transformation in her city landscape. The rapidity of residential property development and the influx of men and business ventures into the city was attributed to the cheap cost of living and land cost (Ankeli, 2020). Residential properties managed by PM in Osogbo metropolis were enumerated based on the numbers managed by the PMs. The total number of properties in this category that were enumerated was 546 out of which, 235 of such properties constituting 43% were randomly selected for the study. The study's target population consist of property management firm which are either professional estate surveying and valuation firms, non-professional firms/quacks that dabbles into the act of managing properties as house agents on behalf of the property owners in Osogbo Metropolis and tenants of residential properties under the management portfolios of the selected PM. The inclusion of the quacks/charlatans in the study become necessary as this group are the most patronised by the property owners and have the highest number of properties in their management portfolio. The total number of practising estate surveying and valuation firms in the city was arrived at through consulting the 2019 directory of the Nigeria Institution of Estate Surveyors and Valuers, and the list obtained were reconciled with the list of Estate Surveyors and Valuers (ESV) practicing firms in Osogbo obtained from the Osun state branch of the Nigeria Institution of Estate Surveyors and Valuers. The reconciliation of the list became necessary as a reasonable proportion of the practicing ESV firms do not have their names listed in the directory. The study population extracted from the directory and the list obtained from the state branch was therefore put at 12 ESV firms. Actual physical enumeration of house agents/non-professional property managers with offices was done. 35 house agents were identified and used for the study; hence, a sample frame of 47 property managers was arrived at and used as the sample size for the study, since the number is within manageable size. For the tenants, 235 tenants. To get a proportionate number of respondents from the sample PMs, 5 respondents were selected from each of the management portfolio of the 47 property management firms picked for the study. Questionnaires designed and used for the study were proportionately administered to the respondents to solicit information on the strategies adopted in the management of property, the level of preparedness of PM towards property management in the post pandemic era among others. A total of 282 questionnaires, (that is, 47 questionnaires administered on PM and 235 questionnaires on tenants) was administered, but only 257 were adequately filled and returned for analysis, representing a 91% response rate.

Relative Importance Index (R.I.I.) was used to rank the variables on tenants' satisfactory level of the management strategies adopted by PM, preparedness for the task in the post pandemic era among others. Frequency counters and simple percentages were used to describe the level of awareness and perceptions of the challenges in the post pandemic era by collating the frequencies of all the variables measured and calculating their percentages and degrees. The variables/indices tested/used in the study were harvested from literature and the responses obtained from the field. The formula for R.I.I. used by Ankeli *et al.* (2020a) and Nuhu *et al.* (2022) was adopted for this study:

$$\text{R.I.I.} = \frac{\sum W}{A*N} = \frac{5n5+4n4+3n3+2n2+1n1}{5N}$$

Where the variables are given the following weights: W= weighting is given to each of the respondents' statements and ranges from 1 to 5, n_5 = strongly agreed; n_4 = agreed; n_3 = uncertain; n_2 = disagreed; n_1 = strongly disagreed, A=Higher response integer (5); and N=Total number of respondents.

RESULTS AND DISCUSSION OF FINDINGS

Property Managers' Profile and Preparedness for Property Management Task in the post Pandemic Era.

To establish the level of preparedness of the PM towards real property management exercise, the suitability of the data collected were measured through information relating to the profile of the property managers and their level of preparedness. Their responses are as presented in Table 1.

Table 1: Property Managers' Preparedness for Management Task in the Pandemic Era

Types of Property Manager	Number	%	How Prepared for the task	%
Professional (ESV)	12	25.5	10	83.3
Non-Professional	35	74.5	07	20
Total	47	100	17	

The Table shows that 25.5% of the responding firms are professional firms while 75.5% are non-professional firms. This shows the level of penetration of charlatans into the property market in Osogbo. 83% of the professional firms sampled shows high level of preparedness in their operational conduct and structures. Only 20% of the non-professional firms exhibited signs of preparedness for the challenges in the post pandemic era as the study observed that records of tenants were not properly kept, no risk assessment plan among others

Property Management Strategies adopted by Property Managers in the Study Area.

The study collected responses on the nature of the strategic management principles adopted in the management of properties by PM. Some of the conventional management strategies extracted from literature and questions were asked on are mode of inspection, tenant selection, rent collection, maintenance among others, while the contemporary strategy include the use/application of modern technology as information and communication technology in property management and the fusion of basic health guidelines in tenancy agreement. The information collected was further screened to know if such strategies are adequate to take care of the contemporary challenges in the post pandemic era and how satisfied the tenants are with the management strategies adopted by the PM.

Table 2 shows the responses of the respondents on the management strategy and the percentages/degree of satisfaction. The cognitive and affective proficiencies of both the PM and tenants were tested. The data obtained on which percentages and degree were computed thereof are data on the management tactics, operational conduct and structure of the firms among others. The Table further revealed that, 65% (234^o) of the PM are charlatans/quacks; hence still adopting the convention management strategy (70%). On the level of satisfaction with the management strategy, about 80% of tenants representing 288^o are not satisfied with the management strategy in use. The dissatisfaction has in part led to high-level default (85% representing 306^o) in rent payment.

Table 2: Management Strategies Adopted by PM and the level of Satisfactions

Management Strategies	Frequencies (N=257)	Percentage (%)	Degree
Number of Properties Managed by PM			
Professionals	90	35	126
Non professionals	167	65	234
Total	257	100	360
Management Strategies			
Conventional	180	70	252
Contemporary	77	30	108
Total	257	100	360
Provision for the Enforcement of COVID-19 Protocol			
Adequate	44	17	61
Not Adequate	213	83	299
Total	257	100	360
Property Inspection Strategies			
Inspections Rarely Done	221	86	310
Inspections Often Done	36	14	50
Total	257	100	360
Satisfaction with the Management Strategies			
Satisfied	51	20	72
Not Satisfied	206	80	288
Total	257	100	360
Observance of Rent Obligations in the post pandemic era			
Frequent rent payment	39	15	54
Accumulated rent arears	218	85	306
Total	257	100	360

Strategic Plan Indices for Property Management in the Post Pandemic Era.

To determine the best practices for property management in the post pandemic era using the contemporary method, some variables/indices were identified and presented to the 47 property managers using Likert scale and ranked on the Relative Importance Index (R.I.I.). Table 3 presented the outcoming of findings and the standing of each of the variables for contemporary property management strategies in the post pandemic era.

Table 3: Strategic plan Indices for property management in the post pandemic era.

Variables/indices	*S.A.	*A	*N	*DA	*S.D.	∑W	R.I.I.	Ranking
*The need for the creation of a risk assessment or contingency plan	36	8	-	2	1	216	0.919	2nd
*Observance of basic health guidelines	25	15	2	5	-	201	0.855	3rd
*Property protection tactics and what to outsource	15	20	2	6	4	177	0.753	5th
*Keeping space users/tenants, visitors and employees safe	40	6	1	-	-	227	0.966	1st
*Property management through remote security practices	24	10	7	6	-	193	0.821	4th

**SA= Strongly Agree; *A= Agree; *N = Neutral; *DA = Disagree; *SD = Strongly Disagree*

Table 3 further shows that all the variables were significant. The strategic plan that will keep space users/tenants, visitors and employees safe is the most critical variable with R.I.I. of 0.966; hence ranked first and the need for the creation of a risk assessment plan with R.I.I. of 0.919 ranking second while property protection tactics and the decision on what to outsource with R.I.I. of 0.753 is the least critical factor though significant.

Despite the myths and misconceptions on the role of PM and the new normal, there are good takeaways from the phenomenon. The pandemic had infiltrated and sapped into every sector of the economy. The real estate investors were unable to reap from their investment and the failure of space users to keep to their lease obligations within the pandemic era were in part due to the neglect of the role of PM and the effect of the pandemic. The glut in the real property market that did not allow business spaces to expand as staff work from home encourages business fund diversifications and revitalization of the need for the use of professional property managers and the adoption of contemporary management strategies. The pandemic reduced business risk but increased the prospect of future rental growth as real property is generally believed to hedge against inflation. The pandemic has increased the high demand for functional urban housing where one can perfectly combine work, leisure and living under the same roof. More so, the new normal made property investors/owners, space users/tenants and designers to recognized and appreciate the need for the integrations of technology into aesthetics and the structural frame of the building, where compact smart structures development and mixed-use properties development are encouraged with a more cautious health and safety requirements of the immediate environment. All these will further necessitate the need for contemporary real property management strategies.

CONCLUSION AND RECOMMENDATION

The study has reassessed property management strategies in the post pandemic era in Osogbo, the Osun state capital. In order to achieve the aim of the study, PM preparedness for the task of real property management in the pandemic era were determined in order to measure the degree of satisfaction tenants derived from the services provided. The outcome shows that most of the professional PM were prepared for the task. Hence, to move beyond the myths and misconceptions of the pandemic, the study recommends the need for an aggressive public enlightenment campaign that could help transform tenants' psycho-cultural perspective on the role of PM and effect of the pandemic, the inclusion of basic health guidelines in property management plans to promoting good health, a harmonious relationship between landlord and tenants where both parties will see each other as partners in progress and ensure sustainable rental growth and city development.

REFERENCES

Akalemeaku, O.J., Nwafor V. I and Nnamani, O. C. (2021). *Property Management in a Pandemic Era: Strategies for Emerging Markets.* 27th Annual Conference European Real Estate Society. June 2 – 5. Kaiserslautern, Germany

Ankeli, I. A (2022). Influencing Factors of Property Use Conversion and Residential Properties Rental Value Trend in Ikeja, Nigeria. *INTREST – International Journal of Real Estate Studies 16(2), 118-128*

Ankeli, I. A., Nuhu, M. B., Saheed, J., Akinremi, A. R., and Tinufa, A. A. (2021). Post-COVID-19 Pandemic and the Emerging Rental Housing Market in Nigeria. *European Modern Studies Journal*, 5(3) 317 – 323

Ankeli, I. A., Adeleke, M. A., Saheed, J., Adepoju, A. S., and Adie, J. S. (2021a). Sick Building Syndrome: The Causes, Management and Effect on Residential Properties Rental Values in Osun, Nigeria. *International Journal of Innovative Science, Engineering & Technology*, 8(3), 103-114

Ankeli, I.A., Nuhu, M.B., Popoola, N.I., Kemiki, O.A., Okoh, S.O., and Omotehinshe, J.O. (2021b). Impact of COVID-19 Pandemic on Tenancy Agreement: The Lesson from an Emerging Rental Housing Market in Nigeria. *Baltic Journal of Real Estate Economics and Construction Management, 9, 78-93.*

Ankeli, I. A., Nuhu, M. B., Sule, A. I., Ankeli, U. C., & Bello, A. T. (2020). Residential Land Use Commercialization and Rental Value Trend in Osogbo, Nigeria. *International Journal of Creative Research Thoughts*, 8(6), 2521-2530

Ankeli, I. A, Nuhu, M.B, Popoola, N.I, Ankeli, U.C and Ojeniyi, A.S (2020a). Gender Disparity in Land Ownership: An Invitation to National Underdevelopment. *International Journal of Creative Research Thoughts.* 8 (6) 4176 - 4185

Ankeli, I.A., Nuhu, M.B, Sule, I.A, Ankeli, U.C and Alade, A.F. (2019). *Land Use Conversions and Rental Value Regime in an Emerging City. The Awareness, Attention and Action*. Proceedings of 74th Research fora International Conference, Hamburg, Germany, 4th - 5th December.

Busari, S., & Adebayo, B. (2020, CNN). Nigeria Records Chloroquine Poisoning After Trump Endorses It for Coronavirus Treatment. Available: https://www.cnn.com/2020/03/23/africa/chloroquine-trump-nigeriaintl/index.html.

D'Ercole, M. (2016). How Changing Dynamics in Commercial Real Estate Are Affecting Property Management. www. 360visibility.com

Fadare, T. (2020). Effective Change Management Strategies in a Workplace During a Pandemic. S.P.A. Ajibade & Co. https://www.mondaq.com assessed on 2/12/21

Gbadegesin, J. T. (2022). Does the COVID-19 affect tenants' adherence to lease obligations in rental market? Property managers' perspective. *Journal of Facilities Management.* Advance online publication. doi:10.1108/JFM-12-2021-0165

Izekor, E.D., Okpuzor, V. N., Morka, E., and Nnaji, P.T. (2020). A Review of COVID-19 Pandemic: Myths, Misconceptions, and Role of Media Education in Nigeria. *Asian Journal of Research in Infectious Diseases*, 5(4), 10-19.

Keni, R., Alexander, A., Nayak, P. G., Mudgal, J., and Nandakumar, K. (2020). COVID-19: Emergence, Spread, Possible Treatments, and Global Burden. Front. *Public Health*, 8, 216. doi: 10.3389/fpubh.2020.00216

Nwachukwu, M. U and Ukpabi, N. I (2008). The Impact of Housing Conversion on Residential Land Use Development in Nigerian Cities: A Case Study of Enugu Metropolis. *Environmental Studies and Research Journal* 1(1), 1-22

Nuhu, M. B., Ankeli, I. A and Salihu, N (2022). Benefits of Rural-Urban Linkages in the Context of Rental Trends: Evidence from Gidan Kwano Area of Minna, Nigeria. *Tropical Journal of the Built Environment (TJOBE)* 3(2), 61 - 72

Oyedeji, J.O. (2020). The Impact of COVID-19 on Real Estate Transaction in Lagos, Nigeria. *International Journal of Real Estate Studies* (INTREST), 14(S1), 107-112

Palm, P. (2013). Strategies in Real Estate Management: Two Strategic Pathways. Property Management, 31(4), 311-325. https://doi.org/10.1108/PM-10-2012-0034

Palm, P. (2011). Customer Orientation in Real-Estate Companies - The Espoused Values of Customer Relations. *Property Management*, 29(2), 130-145

Rachel, B.G., Horsch, A. P., Brian, E. F and Amanda, G.H. (2021). Real Estate Operations in the Coronavirus Era. Ten key Issues Property Owners and Landlords Need to Consider as they Plan to Confront the Pandemic. Pillsbury Winthrop Shaw Pittman L.L.P. www.pillsburylaw.com/en/lawyers/rachel.horsch.html

Salihu, N., Nuhu M. B., Sanni M. L., Sule I. A. and Emmanuel S. G. (2020). *The Effect of Urban Land-Use Planning Regulations on Residential Property Investment Returns: Evidence from Literature.* Proceeding of International Conference: on Sustainable Housing and Land Management, School of Environmental Technology, Federal University of Technology, Minna 3rd – 5th, May.

Sogbon, O., and Olujimi, J. A. B. (2015). Implications of Changing Phases of Property and Land Ownerships on the Physical Development of Akure, Ondo State, Nigeria. International *Journal of Innovation and Scientific Research*, 18(1), 81-89

World Health Organization (WHO) (2020). Supporting Media to Bust Harmful Myths on Coronavirus Disease. Available: reliefweb.int/report/Nigeria/supporting-media-bust-harmful-myths-coronavirus-disease

World Health Organization (WHO) (2020a). Supports Scientifically-proven Traditional Medicine. Available: www.afro.who.int/

Developers Compliance with Urban Residential Development Control Measures in Kaduna Metropolis, Nigeria

Salihu, N.[1], Ankeli, I. A.[2], Nuhu, M. B.[3], Sanni, M. L.[4], Sule, I. A.[3], Aliyu, A. A.[1], Gwamna S. E[5], & Umar, H. Y.[6]

[1]*Department of Estate Management, Bayero University, Kano, Nigeria.*
[2]*Department of Estate Management and Valuation, Federal Polytechnic, Ede*
[3]*Department of Estate Management and Valuation, Federal University of Technology, Minna, Niger State.*
[4]*Department of Urban and Regional Planning, Federal University of Technology, Minna, Niger State.*
[5]*Department of Estate Management and Valuation, Niger State Polytechnic, Zungeru, Nigeria*
[6]*Department of Estate Management, Waziri Umaru Federal Polytechnic Birnin Kebbi*

[1]Snasiru.esm@buk.edu.ng; [2]thonyankeli@gmail.com; [3]mbnuhu@futminna.edu.ng; [4]Sanni.lekan@futminna.edu.ng; [5]suleabbass76@futminna.edu.ng; [6]aaaliyu.esm@buk.edu.ng; [7]emshega@gmail.com; [8]Hamzayaro002@gmail.com

Corresponding author: Snasiru.esm@buk.edu.ng,

Abstract:

This study critically assesses the level of compliance with urban planning and physical development control measures of residential property in Post Covid-19 era in some selected neighbourhoods in Kaduna metropolis. Quantitative research approach was used to collect survey data from real estate firms' portfolio's using Open Data Tool Kit application. Data collected were analysed with the aid of descriptive (percentage, cluster bar-graph) and inferential (ANOVA) statistical techniques. The results show among others that compliance with regulations on numbers of people in a room, room size and setbacks is low this negates part of covid-19 guidelines. Dilapidating housing and ancillary service negatively affects staying at home strategy and clients' willing to pay, thus limiting investors' ability to make repairs and increases the chance of mortgage default because of increasing stunted rental growth. Consequently, the study recommends that with the consistent rise in mutation of the virus, policy makers should formulate and holistically implement policies that capture new residential demand trends that improve quality of life in post pandemic environment. Also, sustainable and all-inclusive campaign strategy is required that accommodate covid-19 protocol for residential building guidelines with a view to curtailing surge in infection rate and decrease mortality rate now and in the future.

Keywords: Compliance, land use, development control measure, residential property, pandemic

INTRODUCTIONS

Population growth in most cities in Sub-Saharan Africa has increased demand for housing. The phenomenon has stimulated squalid residential development in nooks and cranny of cities (Salihu *et al*., 2021) overwhelming most local and central government. This has resulted in inadequate and overstretched basic infrastructure. The mutating nature of the dreaded coronavirus of December 2019 (Covid-19) has gone beyond national and international boundaries including Nigeria. Total/partial lockdown was the first protocol employ by government of many nations in line with World Health Organisation (WHO) guideline Nigeria inclusive. The policy guidelines particularly emphasised total/partial lockdown and social distancing in order to reduce mortality rate by restraining the virus spread. In fact, Covid-19 has globally stress-tested urban system within and across all sectors (particularly the housing sector) and regions and has been exacerbated by the volatile economic shock. Total/partial lockdown and social distancing in Nigerian cities has affected the housing sector (Olanrele and Thontteh 2020) by creating Volatility and hostility in the property market trends living the operators in mystery of tackling the lacuna caused by the global health pandemic. Unquestionably investing in residential properties upturn the disposable income of households (Arimah & Adeogbo, 2000). The pandemic's effect on housing is visible particularly on the income streams of investors and, more pronounced where deteriorating basic housing infrastructure is evidently increasing and overstretched by the Work from Home (WFH) strategy.

Undoubtably, with the new normal the taste and preference of client in terms of housing will be to a large extent guided by social distance-induced demand change (Organization for Economic Cooperation and Development, 2020) which is hoped to address the current health crisis. In simpler terms, consumer's decision in terms of renting or buying a house is anchored primarily on the dynamics of a property type that meets the work from home functionality (Salihu, 2022; Chiwuzie et al., 2019) and have the wherewithal to safeguarding (lower density homes and working remotely) a household from the dreaded pandemic. Hence, household decision is based on the supposition that poor housing condition particularly overcrowding worsens the public health impact of the pandemic (Brandily et al., 2020).

On the other hand, modification/alteration of new, on-going or existing housing in compliance with the specification (spacious housing) of Covid-19 protocol are ways stakeholders might respond to the household social distance induced demand change. In this era, "new normal" consumers'/clients' preference for housing will consistently evolve over time. In fact, the Covid-19 pandemic has unsettled construction efforts in two-folds. First, in terms of new construction and on-going plans for developers' and second distorted real estate plans in terms of inability to pay for habitable housing accommodations (OECD, 2020; Ankeli et al., 2021). Alteration of developers' plans and affordability problem of clients will vary according to regions and also depends on the level of timing and strictness of confinement, socio-economic status and public health crisis. Therefore, compliance scenario will differ across region. Thus, there is need for more research in this domain to unearth regional peculiarity.

It is in the light of the aforementioned, this paper contributes to the body of knowledge that investigate Post Covid-19 in terms of compliance with housing development regulations in the Nigeria property market by assessing the level of compliance of developers to urban planning and physical development control measures in Post Covid-19 era in four selected residential neighbourhoods in Kaduna metropolis, Nigeria.

LITERATURE REVIEW

The outbreak of the Covid-19 pandemic has stress-tested all nations, irrespective of their socio-economic and political status. In fact, the developed nations are worst hit. Uncertainty and economic disruption have been striving both in the corporate and private sphere owing to how to subdue transmission of the virus. In Nigeria, the effect is enormous in the housing sector (Olanrele and Thontteh 2020), these effect might be attributed to non-referral to the planning authority or building regulations in the initial property development stage particularly in the urban areas where development is vivid. Non-adherence to planning regulations affect the intrinsic and extrinsic attributes of housing that are used in determining price (Salihu et al., 2021; Nuhu et al., 2022).

Equally, laxity in implementing planning regulations give developers the latitude to develop property based on profitability index only, allowing for development of property at an extreme latitude (small dwelling unit) which create great concern (Ogbonna et al., 2017) while on the other hand the pandemic is a respiratory infectious disease that require social distancing (spacious environment) as a control measure. For example, structural design standard if not sternly enforced may result to overcrowding (Salihu, 2022). However, overcrowding has demonstrated to worsen the public health impact of the pandemic (Brandily et al., 2020). This is dangerous especially in Nigeria where extended family ties are accommodated. With this recent development Covid-19 can adversely strive and distort the residential property subsector of the economy hence the need for renewed interest in this domain to curtail the unprecedented rental crisis that is looming ahead.

Theoretical framework

This study's theoretical underpinning is the Public Interest Theory on Regulation "PITR" (Christensen, 2010). Applying the theory relative to this study, PITR reinforce the certainty that building development in Kaduna metropolis requires adherence to stipulated planning standards which are mostly enforced by the local or central government through compulsory directive, absolutely issued to improve the inhabitants' overall quality of life in terms of health and economy.

In the past two decades, a number of studies have surface and provide important information relative to compliance with residential urban planning regulations. For example, Odekunle et al. (2019) studied the effect, challenges and way forward in development control, Abubakar et al., (2013) reviewed model of compliance, Bogoro and Nghalmi, (2014) studied knowledge, practice and attitude of development control, Adeogun et al. (2017) concentrated on development control and rental value, Jimoh et al. (2017) did research on nature, extent and effect of development control contravention, Matey et al. (2017) studied zoning standards in areas under customary land tenure, Popoola et al. (2017) worked on legal and institutional framework for development control practice, Ogbonna et al. (2017) did research on compliance with property development, Salihu et al. (2018) studied development control measures and sustainable development goal, Ojo-Fajuru and Ambrose (2018) centred their study on encroachment and causal factors affecting compliance, Ngetich et al. (2016) and Omollo, (2019) concentrated on efficiency of development control, Osuizugbo, (2019) and Onaiwu, (2020) study the public adherence to 'structural' development control while Omollo and Opiyo (2021) did study on urban road planning. But one of the most significant current discussions is the multi-faceted effect of Covid-19 on cooperate and private lives of occupant of the built environment. This multi-faceted effect has triggered further research questions and investigation.

The significance of adherence to housing planning standard in surmounting, aiding and controlling overcrowding cannot be over-emphasised, there has been very little quantitative assessment of compliance level relative to Post Covid-19. More so, taste and preference of consumers in terms of housing changes over a time horizon (Chiwuzie et al., 2019; OECD, 2020). Therefore, it has become imperative to critically assess developers' compliance level with residential development control and physical planning regulations in Post covid-19 era in Kaduna metropolis.

RESEARCH METHODOLOGY

Quantitative research strategy was used for this study; in which primary data (neighbourhood, physical and location attribute) of residential properties were collected from Estate survey and valuation firms in Kaduna metropolis with the aid of cross-sectional survey method. The property type employed for this study comprises one, two and three-bedroom residential property in Unguwan-rimi, Barnawa, Malali and Sabon-tasha. By June 2020 countries were progressively recouping expansionary territory caused by Covid-19 (OECD, 2020) hence this study's data collection time span started from July 2021 to August, 2021. In this study, purposive random sampling technique was used to select 580 residential properties for data collection in these locations (Kjercie and Morgan, 1970; Salihu, 2022). On-site measurement of geometric variables and their out-door spaces were used to collect the primary data. Open Data Tool Kit application checklist was used to enter the data. The collected primary data were subsequently downloaded and put to cleaning and filtering test to check for half-filling of the checklist form. 12 forms were deleted because they were below 85% filled (Pallant, 2011), hence could not be used for further analysis.

Also, criteria for assessment were based on the basic minimum standard of residential development as enshrined in KASUPDA manual of 2017. Consequently, on-site direct observation/checklist were scored based on the principle that where a developer complied with basic minimum standard 1 point is scored and otherwise 0 "non-compliance to basic minimum standard" (Ogbonna et al., 2017). More so, the on-site survey data were ordinal data which later were converted to percentages (percentages data are often treated as continuous data, because the percentage can take on any value along the continuum from zero to 100%) to achieve the study aim. Aggregate horizontal multiple bar-chart were used, for ease of assessing and reporting the level of aggregate compliance of a developer within a neighbourhood or if not to a given regulation while the inter-rate compliance to the regulation were classified as follows 0 - 49% = low compliance, 50 – 100 = High compliance (Ogbonna et al., 2017). Also, one – way ANOVA was further performed on percentage data (continuous data) in order to demonstrate if there is statistically significant difference in mean score of level of compliance among the neighbourhoods.

FINDINGS/DISCUSSIONS

Figure 1 shows the aggregate level of compliance with structural regulations standard in Unguwan-rimi, Barnawa, Malali and Sabon-tasha in the study area. Data indicates that compliance with basic minimum standard of building coverage, fire extinguisher, colour code, store size, certificate of fitness and habitation and, as built drawing are below 50% compliance rate. This indicates that the basic requirement of social distancing was partially achieved because the basic requirement of spaciousness of housing in term of reducing overcrowding to achieve social distancing was below 50%. Regrettably, overcrowding worsens the public health impact of covid-19 (Brandily et al., 2020). This finding on continual reductions in dwelling space by developers in Nigeria property market validate Ogbonna et al. (2017). More so, small room size traps and increases thermal heat which lessens the chances of reducing cross ventilation and overcrowding so as to achieve social distance. Hence in part, contributed to the rate of infection in Kaduna metropolis.

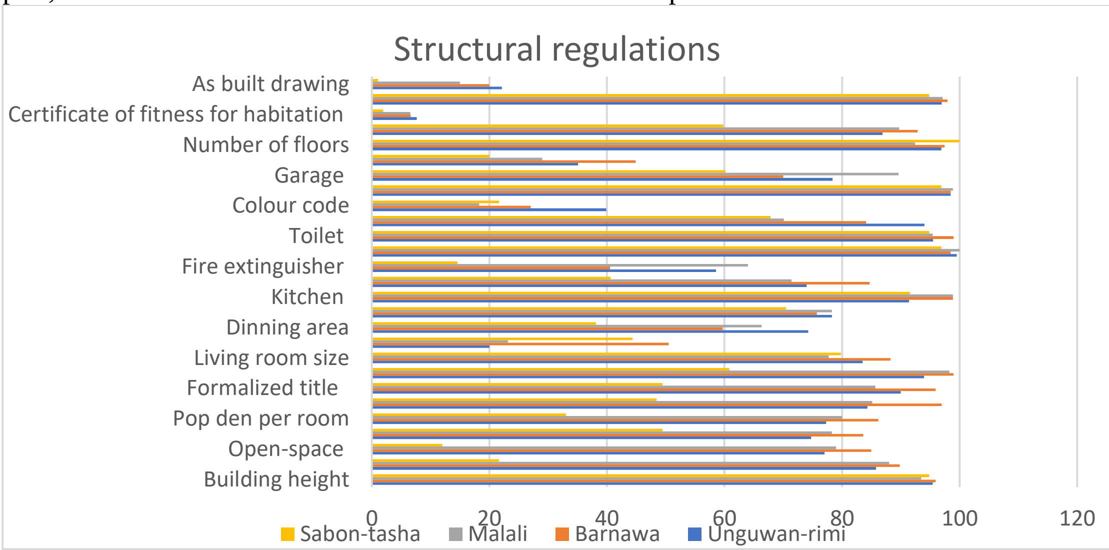


Figure 1: Relative horizontal bar-chart of structural regulations

Figure 2 Compliance with basic minimum standard on neighbourhood regulations in study areas. Inferences from the Figure indicates that regulations on garbage receptacle, drainage system, waste disposal system and security in Sabon-tasha and a general change in use and habitation is below 50% compliance rate. This suggest that the proliferation of waste within Sabon-tasha neighbourhoods is vivid most especially during the lockdown. Also, insecurity is shown to have been at 32.05% suggesting the need for a sustainable security measure in the study area.

Figure 3 presents compliance with location regulations in the study neighbourhoods. Result from the Figure indicates that numbers of trees are below 50%, though the KASUPDA manual of 2017 proscribes that each property should have at most four to six trees depending on the plot size. Tree shade are multi- beneficial to occupants; hence it improves their quality of life (Bello and Yacim, 2013). The shortfall in numbers of trees might have increased the indoor thermal heat of the residential properties to the detriment of the occupants during the total lockdown and work from home approach employed by the Covid-19 presidential task force within Nigeria.

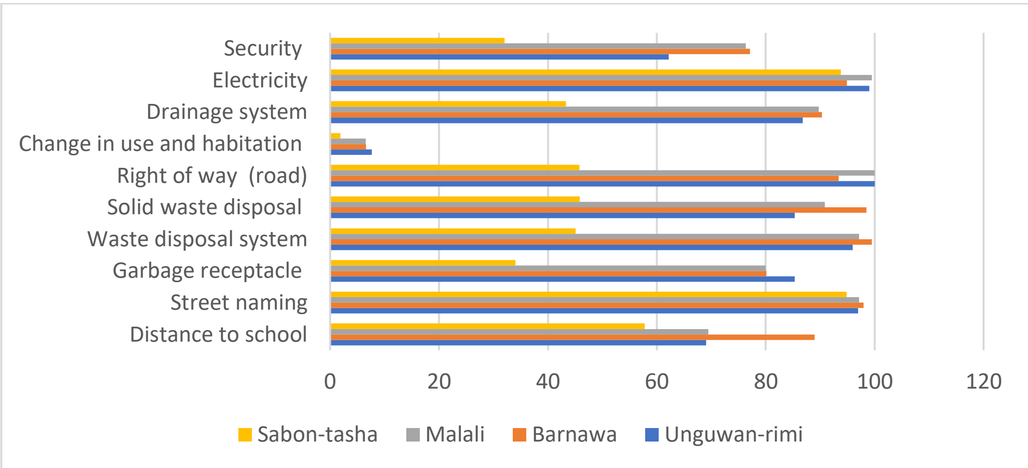


Figure 2: Relative horizontal bar-chart of neighbourhood regulations

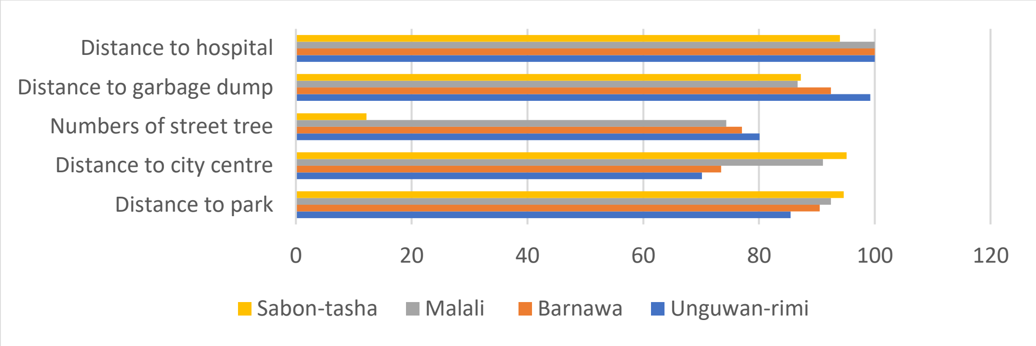


Figure 3: Relative horizontal bar-chart of location regulations

Observation from the results (Figures 1, 2 and 3) on the level of compliance with urban land use planning regulations induced the need for further evaluation of the data obtained from the study areas. ANOVA was further used to establish whether there is equal mean in the level of adherence to ULUPR within the study areas and the results are presented in Tables 1-6.

Table 1 Analysis of variance for compliance with structural regulations

Source	DF	SS	MS	F	P-value
Factor	3	8598	2866	3.50	0.018
Error	104	85099	818		
Total	107	93698			

The result from Table 1 shows that there is significant difference in the mean rate of compliance with structural regulation attributes in the study areas of Unguwan-rimi, Barnawa, Malali and Sabon-tasha with p-value = 0.018.

Table 2. Mean score of structural regulations

```
                                 Individual 95% CIs For Mean Based on
                                 Pooled StDev
Level          N   Mean  StDev   ----+---------+---------+---------+-----
Unguwan-rimi  27  74.44  26.35               (---------*--------)
Barnawa       27  76.57  27.24                 (---------*---------)
Malali        27  72.95  28.54              (---------*--------)
Sabon-tasha   27  54.26  31.97   (--------*--------)
                                 ----+---------+---------+---------+-----
                                    48        60        72        84
```

Pooled StDev = 28.61

Also, the means score Table 2 shows Barnawa has higher mean of 76.57 in compliance with structural regulation attributes as compared with Unguwan-rimi, Malali and Sabon. In simpler terms, Barnawa has a better compliance level in the study area.

Table 3 Analysis of Variance showing Variations in Extent of compliance with neighbourhood regulations in Unguwan-rimi, Barnawa, Malali and Sabon-tasha

Source	DF	SS	MS	F	P-value
Factor	3	7422	2474	3.17	0.036
Error	36	28098	781		
Total	39	35521			

Table 3 shows variations in extent of compliance with neighbourhood regulations in the study neighborhoods. From the Table, the p-value = 0.036 and it infers that there is a significant difference in extent of compliance with neighbourhoods' regulations in Unguwan-rimi, Barnawa, Malali and Sabon-tasha.

Table 4. Mean score of Neighbourhood regulations

```
                                 Individual 95% CIs For Mean Based on
                                 Pooled StDev
Level          N   Mean  StDev   ----+---------+---------+---------+-----
Unguwan-rimi  10  78.83  28.02             (--------*--------)
Barnawa       10  82.74  27.79               (--------*--------)
Malali        10  80.66  28.08              (--------*--------)
Sabon-tasha   10  49.45  27.85   (--------*--------)
                                 ----+---------+---------+---------+-----
                                    40        60        80       100
```

Pooled StDev = 27.94

In addition, the mean score Table 4 showed that, Barnawa has the highest mean = 82.74 in extent of compliance with neighbourhood regulations as compared with Unguwan-rimi, Malali and Sabon-tasha.

Table 5. Analysis of Variance showing Variations in Extent of compliance with location regulations in Unguwan-rimi, Barnawa, Malali and Sabon-tasha

Source	DF	SS	MS	F	P-value
Factor	3	458	153	0.36	0.781
Error	16	6734	421		
Total	19	7192			

Table 5 shows the result of one-way analysis of variance showing variations in extent of compliance with location regulations in the study neighbourhoods with p-value = 0.781 and it infers that there is no significant difference in extent of compliance with location regulations in Unguwan-rimi, Barnawa, Malali and Sabon-tasha.

Table 6. Mean score of location regulations/

```
                                    Individual 95% CIs For Mean Based on
                                    Pooled StDev
Level          N   Mean   StDev   --+---------+---------+---------+-------
Unguwan-rimi   5  86.98   12.78          (------------*------------)
Barnawa        5  86.68   11.11          (------------*------------)
Malali         5  88.90    9.46            (------------*------------)
Sabon-tasha    5  76.64   36.16   (------------*------------)
                                  --+---------+---------+---------+-------
                                   60        75        90       105
Pooled StDev = 20.52
```

Lastly, the result from the mean score Table 6 shows that, Malali have the highest mean score = 88.90 in extent of compliance with location regulations as compared with Unguwan-rimi, Malali and Sabon-tasha.

Conclusion

Findings from the study suggest that compliance with structural regulation was partially achieved because the basic requirement of spaciousness of housing in terms of reducing overcrowding was below 50%. Overcrowding worsens public health impact of covid-19 (Brandily et al., 2020), these findings substantiate Ogbonna et al. (2017) in terms of small internal and housing space.

The findings also show that compliance with neighbourhood regulations regarding change in use and habitation is below 50% indicating that a some percentage of houses in the neighbourhoods have informal status hence aggravate formation of squalor settlements, while Sabon-tasha neighbourhood had a greater percentage of non-compliance in terms of insecurity, garbage receptacle, solid waste disposal, road drainage system suggesting the need for an inclusive sustainable measures to tackle the challenges in the study area.

More so, findings on compliance with location regulations suggest that regulation on number of trees is below 50% compliance. Tree shades are known to have positive effect on occupants hence improve their quality of life (Bello and Yacim, 2013). The short fall in number of trees most undoubtedly intensifies the indoor thermal heat composition of the rooms particularly during the lockdown. Indoor thermal heat in Kaduna metropolis hampered the rate of compliance with Covid-19 presidential task force order (social distance) put in place to reduce the spread of the dreaded virus. Similarly, rise in indoor thermal heat induced change in demand structure (taste and preference) of home seeker to a better housing type that meet their current taste and preference. It is without doubt that the pandemic had induce change in demand structure in some location, this led to voids in residential properties.

It is in view of the finding that this study recommends that policy makers should formulate and holistically implement policies that capture new residential demand trends that improve quality of life in post pandemic environment. This could be achieved through increase in public campaign on sustainable waste disposal and security, maintenance and repairs. Also, planting of trees, need for cross ventilations these will attract client and increase rental and capital appreciation. With a view to curtailing surge in infection rate and decrease mortality rate now and in the future.

REFERENCES

Abubakar, M., Lizam, M., and Yassin, A. (2013). A review on the models of compliance with residential development standard in Nigeria. A paper Presented at the 2nd International Conference on Technology Management Business & Entrepreneurship, Melaka Malaysia. 522-531. 5th December.

Adeogun, A. S., Salihu, N., Wahab, M. B., Raheem, W., and Kemiki, A. O. (2017). Assessment of the impact of development control measure on residential property rental values in Minna metropolis. ATBU Journal of Environmental Technology. 10(2), pp. 101-116.

Arimah, B. C., and Adeagbo, D. (2000). Compliance with urban development and planning regulations in Ibadan, Nigeria. Habitat International. 24(1), pp. 279-294.

Ankeli, I. A., Nuhu, M. B., Saheed, J., Akinremi, A. R., and Tinufa, A. A. (2020). Post Covid- 19 Pandemic and the emerging rental housing market in Nigeria, European Modern Studies Journal. 5(3), pp. 317-323.

Bello, O. Y., and Yacim, J. A. (2014). An assessment of the impact of tree shade on rental value of residential property in Maiduguri, Nigeria. FIG Congress 2014 Engaging the Challenges Enhancing the Relevance Kuala Lumpur, Malaysia 16-21 June 2014.

Bogoro, A. G., and Nghalmi, S. M. (2014). Knowledge, attitude and practices of development control in millennium quarters Yelwa, Bauchi. Nigeria. Journal of Research in Environmental and Earth Sciences. 1(1), pp. 01-11.

Brandily, P., Brebion, C., Briole, S., and Khoury, L. (2020). A Poorly Understood Disease? The Unequal Distribution of Excess Mortality Due to COVID-19 Across French Municipalities. Assessed on 19/01/2022 from https://www.researchgate.net/publication/342857302

Christensen, G. J. (2010). Public interest regulation reconsidered: From capture to credible commitment. A paper presented at the 3rd Biennial Conference, University College, Dublin, 17th- 19th June, 2010. Retrieved December 12, 2019 from www.regulation.upf.edu/dublin-10-papers/1J1.pdf.

Chiwuzie, D. I., Dabara, T. M., Adenipekun, E. M. P., and Ajiboye, B. O. (2019). Tenant's demand for structural attributes in residential properties: the case of Ede, Nigeria: In Laryea, S. and Essah, E. (Eds) Procs West Africa Built Environment Research (WABER) Conference, 5-7 August 2019, Accra, Ghana, 1063-1076.

Jimoh, B. A., Al-Hasan, A. Z., Imimole, W. O., and Ahmed, M. B. (2017). Contravention of development control measures in Auchi, Edo State, Nigeria, Applied Science Reports. 20(1), pp. 30-34.

Krejcie, R. V., and Morgan, D. W. (1970). Determining sample size for research activities. Educational and Psychological Measurement. 30(3), pp. 607-610.

Matey, E., Lengoiboni, M., & Koeva, M. (2017). Zoning standards and compliance in the context of customary tenure system: A casesStudy of West Ashiyie, Adentan Municipality in Ghana. Proceeding of FIG Working Week 2017 Surveying the world of tomorrow - From digitalisation to augmented reality Helsinki, Finland, May 29–June 2, 2017.

Ngetich, K. J., Opata, G. P., and Mulongo, L. S. (2016). Making urban planning and development control instruments work for Kenyan Cities: The case of the City of Eldoret. Journal of Emerging Trends in Economics and Management Sciences. 7(4), pp. 246-254.

Nuhu, M. B., Ankeli, I. A., and Salihu, N. (2022). Benefits of Rural-Urban Linkages in the Context of Rental Trends: Evidence from Gidan Kwano Area of Minna, Nigeria. Tropical Journal of the Built Environment. 3(2), 61-72.

Odekunle, J. F., Akindele D. B., and Adebayo G.O. (2019). The problems and challenges of development control in Abeokuta-west zonal planning area, Ogun State, Nigeria. African Journal of Economics and Sustainable Development. 2(1), pp. 9-27.

Ogbonna, C. G., Obinka., A. N., and Aguguo, G. U. (2017). Property development and land use planning regulations in Nigeria, International Journal of Environment, Agriculture and Biotechnology. 2(4), pp.1694-1707.

Ojo-Fajuru, O., and Ambrose, A. (2018). Development control regulations compliance: Paradigm change to reinvent disrupted public spaces and make future great place in Ado-Ekiti, Nigeria. Civil Engineering and Architecture. 6(1), pp.1-17.

Olanrele, O., and Thontteh, E. (2020). COVID-19 and the 'New Normal': Implications for the Nigerian Real Estate Sector. Centre for Housing and Sustainable Development, University of Lagos, Akoka, Lagos.

Omollo, W. O (2019). Application of planning standards in regulating Road reserves (Case Study: Kisii Town in Kenya). International Journal of Architectural and Urban Development. 12(2), pp. 1-18.

Omollo, W. O., and Opiyo, R. O (2020). Appraisal of compliance with land subdivision planning regulations in residential neighbourhoods. International Journal of Human Capital in Urban Management. 5(2), pp. 125-138

Onaiwu, D. N. (2020). Assessment of Public Compliance with Development Control Regulations in Auchi, Edo State, Nigeria. The Indonesian Journal of Planning and Development. 5(2), pp. 78-86.

Organisation for Economic Cooperation and Development (2020). Housing Amid Covid-19:
Policy Responses and Challenges. Accessed on 18/012/22 from https://www.oecd.org
Osuizugbo., I. C. (2019). An appraisal of building control and regulations practice in Nigeria:
Project managers' perspectives. Organization, Technology and Management in Construction. 11(1), pp. 2022–2033.
Pallant, J. (2011). *SPSS survival manual*. New South Wales, Sydney: Allen and Unwin.
Popoola, A. S., Adeyemi, A. A., Arohunsoro, S. J., and Aina, O. S. F. (2017). Urban Development Practices in Ado-Ekiti, Ekiti State, Nigeria. Donnish Journal of Geography and Regional Planning. 3(2), pp. 010-016.
Salihu, N. (2022). Development control measures in Post Covid-19 era in Nigeria: Emerging
Rental Market. Journal of Management Sciences. 4(5), 83-96.
Salihu, N., Nuhu M. B., Sanni L. M., Sule I. A., and Gwamna S. E. (2021). The effect of urban land-use planning regulations on residential property investment returns: Evidence from Literature: Sustainable housing and land management (*Proc*. of 3rd School of Environmental Technology International Conference'SETIC2020' Federal University of Technology, Minna, Nigeria 3-5 May 2021).
Salihu, N., Kemiki, A. O., and Gwamna, E. (2018). Urban development control as a viable
measure for achieving sustainable development goals: Contemporary Issues and Sustainable Practices in the built environment. Minna, Niger State. (Proc. of 2nd School of Environmental Technology International Conference'SETIC2018' Federal University of Technology, Minna, Nigeria 10-12 April 2018).
World Health Organisation (2007). Retrieved from: http://www.who.int/csr/resources/publications/csrpublications/en/index7.html on 26/02/2022.

Macro Economic Determinants of Rental Values of commercial Real Estate in Ilorin, Nigeria

Abdulmalik, F.B.[1a] & Udoekanem, NB.[1b]
[1]*Department of Estate Management and Valuation, Federal University of Technology Minna, Nigeria.*
[a]phbeentah@gmail.com; [b]namnsoudoekanem@futminna.edu.ng
corresponding author: phbeentah@gmail.com

Abstract:

The goal of any real estate investor is to maximize return. However, property investment is characterized by a huge initial capital outlay and is influenced by some key factors. Thus, it is pertinent that the economics of rent influencing factors are understood to enhance property market penetration. This study assessed the influence of these key factors on commercial property rental variation in the commercial areas of Ilorin, Kwara State. Primary data for the study were collected from commercial property occupiers and estate surveyors and valuers operating within these areas. Secondary data for the study included macro-economic variables obtained from the National Bureau of Statistics (NBS) and the Central Bank of Nigeria (CBN). The study utilized descriptive analytical techniques and multiple regression to analyze the variation in rental performance and the influence of macroeconomic factors on the rental value and general investment performance of commercial properties in Ilorin. Results of data analysis revealed an increasing trend of rental values over the years under study, influencing economic factors. With the economic challenges currently faced due to the COVID-19 pandemic, the economic implications of the pandemic on the rental performance of commercial properties in the city require a carefully designed strategy to minimize the vacancy rate.

Keywords*: Commercial Real Estate, Rents, Rental Variation, Ilorin*

1.0 Introduction

In common parlance, "real estate" denotes ownership of or an interest in property owned by a person (Ugwu 2018). The terms "real estate" and "real property" generally indicate the same thing. Real estate and other assets determine the wealthiest people's worth around the globe. When utilized for purposes other than owner-occupier, notably for commercial use, it has evolved into a repository of wealth for generating returns (rents). Rent is a regular payment for real estate interest. It is a turnover for the potential use of real estate as an investment in various scenarios (Ugwu 2018). A significant difficulty for real estate investors in Nigeria has been recognized to be selecting the best alternative form of investment (Oyewole 2013). Investment opportunities abound among the several real estate-related options open to prospective investors, with a critical choice among them being an investment in commercial real estate. According to Boon and Higgins (2007), commercial real estate developments are an essential component of the urban environment. The report portrays commercial real estate as a defining characteristic and a driving force behind urban growth. Over time, it has evolved into a sign of a functional city in terms of both its economics and aesthetics. Participants in the real estate market use rental value as a benchmark to evaluate the economic feasibility of their investment commitment (Boon & Higgins, 2007).

Real estate investments in commercial properties depend on the developers' return in the form of "rent" to prosper. Early theories of rent, like those put forth by Barlowe as reported by Barkley (1986), saw variations in rent as the result of some factors. Notable among these factors are spatial location and accessibility brought on by distance and transportation costs concerning other significant locations in a city, depending on the needs of people (Boon & Higgins, 2007; Udoekanem *et al*., 2014). The demand for a property represents the profitability or utility that can be derived from using it, even though commercial properties' primary goal is financial gains. The higher the rent the user is ready to pay for a certain property, the more advantage they stand to earn from it. Benefits derived from the property have been linked to the complexities of the real estate market, particularly the interplay between supply and demand for houses. Rent is viewed in this context as a factor of supply, demand, and other external factors, whose composition fluctuates in the context of the coverage of the real estate market (whether the property market is local, regional, or international). Due to the diversity of real estate, rents passing on properties are certain to be affected. These elements may be either intrinsic or extrinsic to the specific real estate market. These factors include proximity and complementarity (Iroham 2014), size, structural traits (Iroham 2014; Tay et al. 1999), accessibility, and location (Iroham 2014; Michael et al. 1998). Over the years, researchers in the field have carried out several studies to assess the effectiveness of real estate investments. A few others have evaluated the relative success of real estate investment alternatives, particularly residential and commercial investments. Prominent among these were Baker (2001), Tonelli *et al*. (2004), Bello (2003), and Udobi *et al*. (2018).

Oyewole (2013), Iroham (2014), and Udobi et al. (2018) all found that investing in commercial real estate outperforms investing in residential property. However, Ugwu (2018) found that the rental value of both residential and commercial real estate in Nigeria varies. This has to do with the degree of risk often connected to investments in commercial real estate. Therefore, an accurate assessment of variances in expected return from such investment possibilities has become necessary. The determination of the causes of these rental changes is also crucial. Therefore, this study aims to assess the patterns of commercial real estate investments and the factors that affect the variation in commercial real estate rental rates in Ilorin, Nigeria.

2.0 Methodology

The survey research design was chosen for this investigation. To choose samples from the total population for data analysis, a survey design was adopted. This makes it possible to determine the traits of the population based on the sample. To get the necessary data from the pertinent population, a well-structured questionnaire was utilized to collect the essential data from the relevant population which in this case, were reached through the directories of the Nigerian Institution of Estate Surveyors and Valuers, the Kwara State Bureau of Land, and the Kwara Inland Revenue Service. For the examination of economic factors, official information from the Central Bank of Nigeria and the National Bureau of Statistics were also utilized.

2.1 Study population

Within the three main axes/zones of commercial activity in Ilorin, the study population consists of tenants of retail commercial shopping complexes and managing partners of estate surveying and valuation firms. As a result of the findings from Oyewole (2013), the commercial area in Ilorin has been divided into these categories. Commercial Axis A (which includes Oja Tuntun (New Market)/Oja Oba (Emirs Market), Gambari Axis, and Ipata/Ojagboro Axis), Commercial Axis B (Murtala Muhammad Road/ Yoruba road, Unity/ Taiwo road, and Offa Garage), and Commercial Axis C (Fate Road and Umar Audi/ University Road (Tanke)) are the axes/zones that are taken into consideration

2.2 Data Analysis

Different data analysis tools and techniques were employed in this study to proffer answers to specific objectives. Descriptive and inferential statistics utilized for the analysis of data are shown in Table 1.

Table 1: Method of data analysis and data requirements for the study.

S/N	Objectives	Data Requirement	Source	Method of Data Analysis
1	Examine the trend of investment in commercial properties in Ilorin.	The number of commercial properties (Shops and shopping complexes) developed in Ilorin between 2005-2020	Field Survey	Time Series Analysis and Simple descriptive statistics using tables and charts
2	To assess the rental performance of commercial real estate in Ilorin for the period of the study	Average rental data of unit shops in commercial properties developed between 2005-2020	Field Survey Data	Average rental growth rate, rental index, and standard deviation
3	Establish the macro-economic factors that determine rental variation in commercial real estate in Ilorin	GDP, Inflation rate, Exchange Rate, Rental values of Commercial Properties, Vacancy rate, and Rate of Employment in the service sector.	The central bank of Nigeria (CBN) and the National Bureau of Statistics (NBS)	Likert Scale, Tables and regression analysis

3.0 Results and Discussions

Inferences drawn from the data obtained are discussed in this section along with the analysis of the field data. Data on commercial properties in various Ilorin locales were collected via distributed questionnaires and were categorized into zone A, zone B, and zone C. Registered estate surveyors, registered estate valuers, and the residents of these properties were contacted for information. However, secondary information on the macroeconomic factors influencing the market for commercial real estate in Ilorin was obtained from the National Bureau of Statistics Bulletins and the Central Bank of Nigeria.

3.1 Questionnaire Administration

The registered estate surveying and valuation firms were given 26 questionnaires (Table 2), 21 of which were retrieved and correctly completed. On the other hand, 120 out of 150 questionnaires (Table 3) given to property occupiers were recovered (80%). Table 3 details how the questionnaire was distributed to the tenants of the commercial complexes.

Table 2: Questionnaire Administration Summary (Estate Surveying and Valuation Firms)

Questionnaires administered	
The total number of firms identified	26
Total Questionnaires administered	26
Total number of questionnaires retrieved	21
Percentage of questionnaires retrieved	80.8

Table 3: Questionnaire Administration Summary (Property Occupiers)

Location of Properties	No. of Questionnaires Distributed	No. of Questionnaires Retrieved	Respondents' percentage
Zone A	40	32	80.0
Zone B	50	40	80.0
Zone C	60	48	80.0
Total	**150**	**120**	**80.0**

3.2 Findings and Discussion of Results

3.2.1 Trends in commercial property Investment in Ilorin.

Average Rental values of unit shops in commercial shopping complexes in all three zones between 2005 and 2020

Data on the streams of rental income of commercial complexes used for this study was obtained from the seasoned Estate Surveyors in Valuers in practicing firms within the Ilorin metropolis. For this study, the rental data obtained were grouped into three according to the location of the properties within the commercial zones identified by the researcher. As such all groupings for the study are made according to the zones they fall in, in the researchers' grouping of commercial areas in the study area.

Table 4 above reveals a progressive annual increase in rent at different magnitudes throughout the study period. This indicates a healthy trend in rental movement in commercial real estate investment in Ilorin.

3.2.2 Annual Rental Value Time Series Analysis of commercial real estate in Ilorin

Time series analysis involves the analysis of data collected over a period. It involves the identification of trends, seasonality, and cyclicity in the collected data. In this study, the data collected is the annual rental value of properties. Time series analysis implemented in this section help to identify internal structures in the rental value data collected. However, to carry out time-series analysis on a given data, a common assumption referred to as stationarity must be established. In our data shown in Figure 1, seasonality cannot be said to exist however a clear trend of an increase in the rental value of properties can be observed. Results of the time series forecast of the annual rental value of properties in zone A are shown in Figure 1.

Table 4:Average Rental values of units of shops in the sampled commercial complexes in Ilorin.

Year	*Mean Annual Rent in ₦0,000*		
	ZONE A	***ZONE B***	***ZONE C***
2005	*35.5*	*30.30*	*21.82*
2006	*35.5*	*30.45*	*21.88*
2007	*35.5*	*31.09*	*21.93*
2008	*35.7*	*33.05*	*22.91*
2009	*31.8*	*33.55*	*23.23*
2010	*28.3*	*38.27*	*23.29*
2011	*28.0*	*37.62*	*30.28*
2012	*28.4*	*38.52*	*30.51*
2013	*28.6*	*42.20*	*30.64*
2014	*28.8*	*44.51*	*29.48*
2015	*30.6*	*45.90*	*30.14*
2016	*30.6*	*47.71*	*33.24*
2017	*31.8*	*50.36*	*34.66*
2018	*32.2*	*52.82*	*35.12*
2019	*32.7*	*53.30*	*35.32*
2020	*33.0*	*54.10*	*35.20*

Moving average time series analysis technique which is a straightforward approach was adopted to infer what the future rental values would look like. From both figures Figure 1 and 2, a continuous increase in the rental value of properties in zone A is observed. This increase may be caused by either inflation, shortage of rental space due increase in the number of businesses. Given the current economic reality of the country with a high rate of unemployment and citizens venturing into businesses of various forms, could explain the high rental values in the future asides from the obvious effect of inflation. A similar trend as in Zone A is observed in the time series forecast of the annual rental value of Zone C (Figure 2). So, it is clear from both zones that the annual rental values of properties would increase in the next few years. The question that remains is given the economic conditions of the residents in these zones; can this increased value be affordable by most rental property seekers.

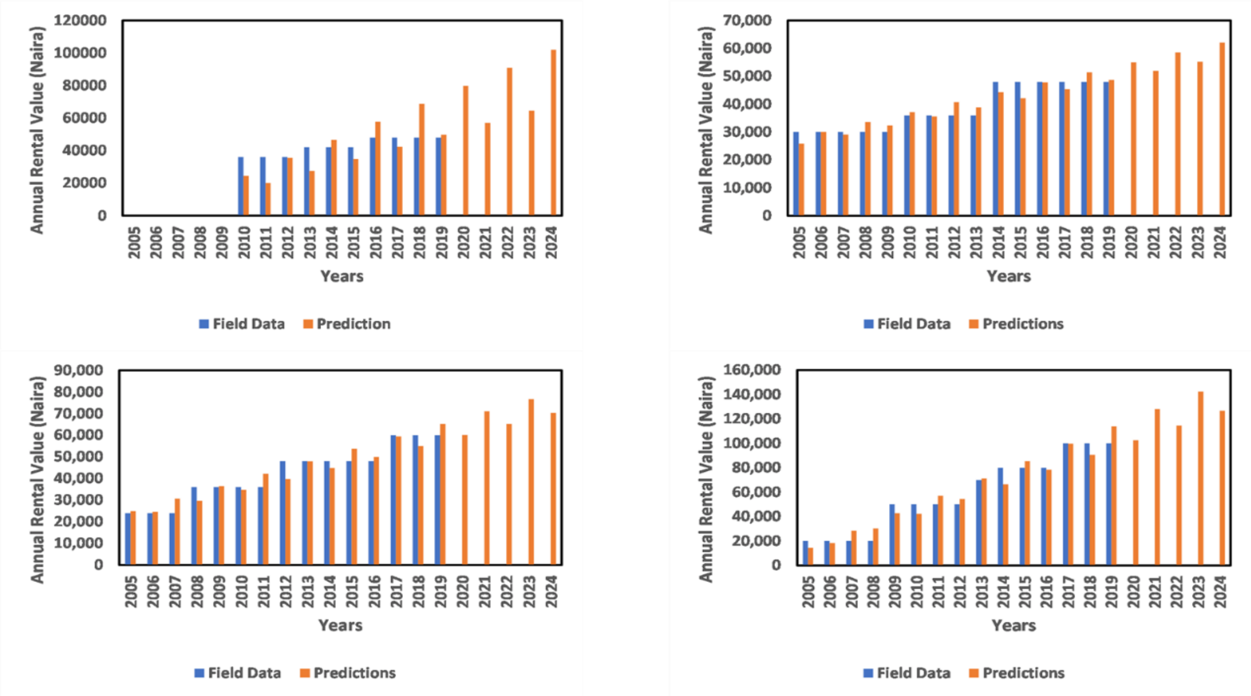


Figure 1: Time series forecast of properties in Zone A.

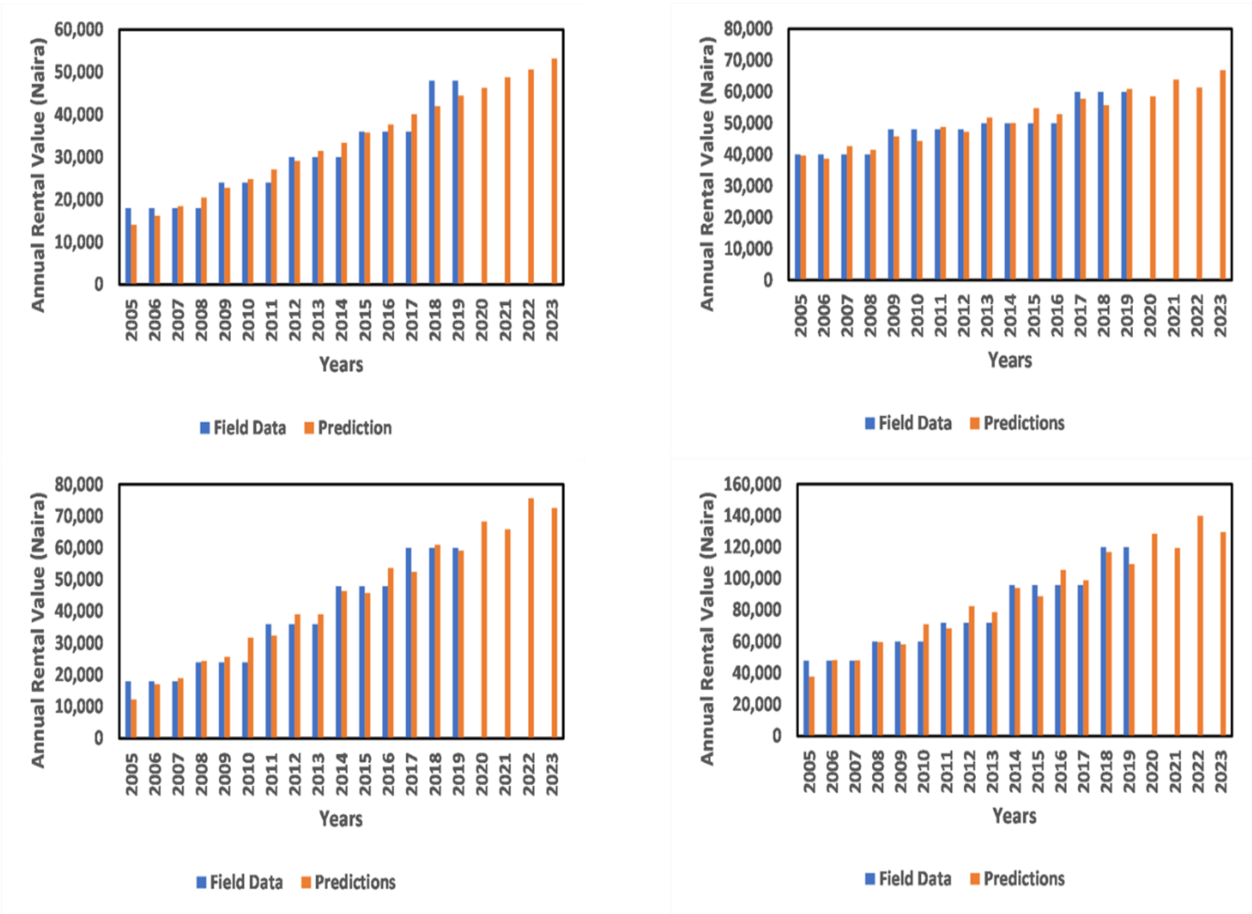


Figure 2: Time Series forecast foe Zone C.

3.3.1 Rental Performance of Commercial Real Estate Investment in Ilorin

Investment opportunities in commercial real estate may become less appealing over time. However, in today's advanced society, more data-driven market analysis is necessary to gain insight into the local real estate market dynamics. The average rental trend for commercial real estate investment is shown in Table 4 for each of the three zones. It demonstrates a consistent annual rent increase with varying magnitudes throughout the study. This suggests a positive trend in the rental market for commercial real estate in Ilorin. More specifically, it accounts for changes brought on by changes in economic and controlling factors by reflecting variations in the annual rental value of properties. So, from an investor's perspective, the study field offers investment opportunities.

According to

Table 5, Zone B has the fastest growth rate, with an average annual growth rate of 179%, while Zones A and C experience slower growth rates of 58% and 63%, respectively. As a result, investors can recover their initial investment cash earlier by renting out homes in Zone B, where rent increases more quickly. A shrewd investor will almost certainly invest in a place that guarantees a rental growth rate of over 100% annually, but this may carry a risk because the growth rate appears bullish. The standard deviation, which depicts the likelihood of obtaining this average, is also shown in

Table 5. The standard deviation measures the departure from the mean. It serves as a gauge for the dependability of investment possibilities. Furthermore, Zones C and A are suitable for risk-averse investors, whereas zone B, which offers larger returns, is suitable for risk-seeking investors. The Coefficient of Variation represents rent

inconsistency, therefore the lower its number, the more accurate the estimate and the safer and better the investment choice.

Table 5:Rental growth rate and performance in Ilorin.

Years	Zone A	Zone B	Zone C
2005	0.00	0.00	0.00
2006	0.20	1.02	0.07
2007	0.50	2.06	0.07
2008	2.17	2.25	1.85
2009	0.42	2.15	0.71
2010	0.27	3.41	0.06
2011	1.04	1.81	1.92
2012	0.67	0.47	0.41
2013	0.57	2.89	0.14
2014	0.48	1.79	0.76
2015	1.29	0.68	0.62
2016	0.14	1.49	0.23
2017	0.70	3.05	1.11
2018	0.45	1.20	0.65
2019	0.33	0.80	0.15
2020	0.31	1.02	0.67
Average Growth Rate	0.58	1.79	0.63
Standard Deviation	0.53	0.97	0.60
Coefficient of Variation	**0.91**	**0.54**	**0.95**

3.2.3 Influence of Macro Economic Factors on Rental Property Values

External factors with a potential impact on the Ilorin real estate market were taken into consideration to gain a deeper understanding of the variables affecting rental values and variance. Geopolitical, economic, and environmental developments that have an impact on a nation's economy may or may not be under the authority of a government or its people are known as macroeconomic factors. DXX among others, are indications of economic growth or decline. The Central Bank of Nigeria provided the data for the study. Table 6 displays changing macroeconomic factors that have an impact on the whole country and, consequently, the local economy of the Nigerian Market for all items in their original form.

The cost of investment is high in the field of property management, which has an impact on the price at which it can be traded. The dynamics of the general national economy also have an impact on this price. According to the data, the GDP peaked in 2010 and declined significantly (by a substantial percentage loss of 25%) to its lowest level in 2019. 2005 saw the highest inflation rate, at 17.9%. This was ascribed to the significant merger and acquisition activity that year in Nigeria's banking industry. However, the interest rate on real estate loans reached an all-time high of 34.5% in 2017, fell by 4% in 2018, and has since maintained a high rate of 30%. This can be ascribed to the rising demand for loans to pay for the significant recent investments made in housing and the real estate industry. The table also demonstrates that up until 2016, real estate was a significant contribution to the GDP, but ever since then, it has been consuming revenue from other industries. With bad debt accrual at 29.50% in 2019, real estate contribution was at its lowest point. The exchange value of the naira has fallen to an all-time low, recorded at 412.99 to the dollar in 2021, and has continued to decline ever since. This can be ascribed to the nation's struggling economy as well as the rising domestic and global demand for the dollar. As a result, the government must devise sound financial and economic measures to stop the inflationary trend that has increased the rental value of the commercial real estate.

Table 6: Macro Economic Factors Influencing the Dynamics in the Nigerian Property Market.

Year	*Annual GDP (₦)*	*Real Estate Contribution to GDP (₦)*	*Inflation (%)*	*Interest Rate on Real Estate Loans (%)*	*USD Exchange Rate*
2005	*37,474,949*	*2,408,824*	*17.9*	*17.95*	*128.5*
2006	*39,995,505*	*2,690,066*	*8.2*	*17.26*	*126.5*
2007	*42,922,408*	*3,005,425*	*5.4*	*16.94*	*116.3*
2008	*46,012,515*	*3,359,764*	*11.6*	*17.01*	*130.75*
2009	*49,856,099*	*3,727,342*	*12.5*	*19.12*	*147.6*
2010	*54,612,264*	*4,127,988*	*13.7*	*17.14*	*148.67*
2011	*57,511,042*	*4,145,866*	*10.8*	*16.25*	*156.2*
2012	*59,929,893*	*4,379,937*	*12.2*	*17.86*	*155.27*
2013	*63,218,722*	*4,904,637*	*8.5*	*20*	*155.2*
2014	*67,152,786*	*5,155,728*	*8.0*	*22*	*167.5*
2015	*69,023,930*	*5,264,696*	*9.0*	*24*	*164.5*
2016	*67,931,236*	*4,903,605*	*15.7*	*28*	*196.5*
2017	*68,490,980*	*4,694,391*	*16.5*	*34.5*	*304.5*
2018	*69,799,942*	*4,471,862*	*12.1*	*27*	*305.5*
2019	*51,860,102*	*3,152,803*	*11.4*	*30*	*306.5*
2020	*-*		*13.25*	*30*	*379.5*
2021	*-*		*16.98*	*30*	*412.99*

SOURCE: The Central Bank of Nigeria Annual Bulletin, 2022

Table 7 demonstrates that the macroeconomic factors considered can account for the 21.4% variation in rental values of the business complexes in Zone A. Except for GDP, all of the parameters taken into account are true of this. Additionally, macroeconomic factors can account for 86.7% of the fluctuation in the prices of commercial real estate in zone B and 78.2% in zone C. GDP in Zone A has a negative number of –0.493, meaning that a 1% rise in GDP results in a reduction in rent of $49.3. However, this is not the case in a perfect society. It suggests a weakening economy. According to the theory that inflation has a positive effect on rental value, an increase in the general level of prices will inevitably result in a matching rise in the rental values of commercial properties in Zone A. However, it returns a positive value of 0.485 and 0.433, indicating that a 1% increase in GDP would result in an increase in zone B and C rent by 48.5% and 43.3% respectively.

Table 7: Coefficients of Regression Analysis of Macro-economic factors and the Rental Values of Real Estate in Ilorin

Model	*Zone A*	*Zone B*	*Zone C*
	(Unstandardized Coefficients B)		
Constant	*27.73*	*25.81*	*22.83*
GDP growth Rate	*–0.493*	*0.485*	*0.433*
Inflation	*0.93*	*–0.438*	*–243*
Interest on Real Estate Loans	*0.070*	*0.635*	*0.256*
Real Estate Contribution to GDP	*0.445*	*–0.528*	*–0.491*
Exchange Rate	*0.007*	*0.035*	*0.019*
R^2	*21.4*	*86.7*	*78.2*

Conclusions

Based on the findings from the study it can be deduced that:

1. The trend of the rental value is rising and will keep rising over the next two years.

2. Inflation, exchange rates, real estate loan interest rates, GDP, location and accessibility, stock availability, neighborhood quality, security and safety, and other variables all affect how much commercial real estate is worth.

3. According to the report, the market for commercial real estate in Ilorin can increase by up to 100% annually. The time series analysis of a value prediction made using the zone's average rent suggests this possibility.

Acknowledgments

We thank the department of Estate Management and Valuation at the Federal University of Technology Minna for their cooperation and for giving us the go-ahead to publish this work. Furthermore, the people and government organizations participating in this initiative are thanked.

References

Aderamo, A. J. (2002). The structure of intra-urban road network development in Ilorin, Nigeria. *Global Journal of Social Sciences*, *1*(1). https://doi.org/10.4314/gjss.v1i1.22777

Alexander, K. (2013). Facilities management: Theory and practice. In *Facilities Management: Theory and Practice*. https://doi.org/10.4324/9780203475966

Appraisal institute. (2013). *Understanding the Appraisal*.

Baker, B. (2001). *Residential Rental Real Estate: An Investment in Need of a Theory*. Department of Accounting & Finance, Faculty of Business & Economics, Monash University.

Barkley, P. W. (1986). Barlowe, Raleigh. Land Resource Economics: The Economics of Real Estate, 4th ed. Englewood Cliffs NJ: Prentice-Hall. *American Journal of Agricultural Economics*, *68*(4), 1030–1030. https://doi.org/10.2307/1242159

Bello, O. M. (2003). A Comparative Analysis of the Performance of Residential Property Investment and Investment in Securities in Lagos, Nigeria. *Journal of Nigerian Institution of Estate Surveyors and Valuers*, *28*(1).

Blackledge, M. (2009). Introducing Property Valuation. *Journal of Property Investment & Finance*. https://doi.org/10.1108/14635781311293015

Boon Foo, N. G., & Higgins, D. (2007). Modelling the Commercial Property Market: An Empirical Study of the Singapore Office Market. *Pacific Rim Property Research Journal*, *13*(2), 176–193. https://doi.org/10.1080/14445921.2007.11104229

Born, W., & Pyhrr, S. (1994). Real Estate Valuation: The Effect of Market and Property Cycles. In *Journal of Real Estate Research* (Vol. 9, Issue 4, pp. 455–485). https://doi.org/10.1080/10835547.1994.12090765

Giussani, B., Hsia, M., & Tsolacos, S. (1993). A Comparative Analysis of the Major Determinants of Office Rental Values in Europe. *Journal of Property Valuation and Investment*, *11*(2), 157–173. https://doi.org/10.1108/14635789310031487

Ibrahimly, C., & Alipour, H. (2017). Mechanisms of regulation of commercial activities in variable demands of the global economy. *Marketing and Branding Research*, *4*(1), 14–24. https://doi.org/10.33844/mbr.2017.60366

Iroham, C. O. (2014). Assessing the Trend in Rental Values of Commercial Properties Along Oyemekun Road Akure, Nigeria. *International Journal of Sustainable Land Use and Urban Planning*, *1*(2). https://doi.org/10.24102/ijslup.v1i2.380

Iroham, C. O., Ogunba, O. A., & Oloyede, S. A. (2014). Effect of Principal Heuristics on Accuracy of Property Valuation in Nigeria. *Journal of Land and Rural Studies*, *2*(1), 89–111. https://doi.org/10.1177/2321024913515104

Kothari, C. R. (2004). *Research Methodology, Methods and Techniques*. New Age International (P) Limited.

Marshall, P. (1976). Equated yield analysis: a valuation method of the future? In *Estates Gazette* (Vol. 239).

Michael, B., Colin, L., & Bryan, D. M. (1998). *The economics of commercial property markets*. Routledge.

Ogunleye, B. M. (2015). Analysis of Investment Performance of Residential Property in Government Housing Estates in Akure, Nigeria. *Journal of Emerging Trends in Economics and Management Sciences (JETEMS)*, *6*(3), 193–201.

Olanrewaju, R. (2009). The Climate Effect of Urbanization in A City of Developing Country: The Case Study Of Ilorin, Kwara State, Nigeria. *Ethiopian Journal of Environmental Studies and Management*, *2*(2), 67–72. https://doi.org/10.4314/ejesm.v2i2.45921

Oni, A. O. (2009). *Developing Predictive Models of Commercial Property Values in Emerging Economy: Case Study of Ikeja, Nigeria*. *1977*, 1–23.

Oyegun, R. O. (1985). The Use and Waste of Water in a Third World City. *GeoJournal*, *10*(2), 205–210.

Oyewole, M. O. (2013). A Comparative Analysis of Residential and Retail Commercial Property Investments Performance in Ilorin, Nigeria. *Journal of Economics and Sustainable Development*, *4*(3).

Plazzi, A., Torous, W., & Valkanov, R. (2008). The Cross-Sectional Dispersion of Commercial Real Estate Returns and Rent Growth: Time Variation and Economic Fluctuations. *Real Estate Economics*, *36*(3), 403–439. https://doi.org/10.1111/j.1540-6229.2008.00218.x

Ricardo, D. (1817). On The Principles of Political Economy and Taxation. *History of Economic Thought Books*, 379.

Scarrett, D. (2008). Property Valuation: The five methods, In *Property Valuation: The five methods, Second edition*.

Schoenmaker, J. D. A. (2016). *Commercial real estate development and valuation in the Netherlands*. University of Groningen.

Slade, B. A. (2000). Office Rent Determinants During Market Decline and Recovery. *Journal of Real Estate Research*, *20*(3), 357–380.

Tay, R., Lau, C., & Leung, M. (1999). The Determination of Rent in Shopping Centers: Some Evidence from Hong Kong. *Journal of Real Estate Literature*, *7*(2), 183–196. https://doi.org/https://doi.org/10.1023/A:1008704604930

Tonelli, M., Cowley, M., & Boyd, T. (2004). Forecasting Office Building Rental Growth Using a Dynamic Approach. *Pacific Rim Property Research Journal*, *10*(3), 283–304. https://doi.org/10.1080/14445921.2004.11104164

Udechukwu, C. (2006). *Principles of valuation*. Treem Nigeria LImited.

Udobi, A. N., Onyejiaka, J. C., & Chikwado, N. G. (2018). Analysis of The Performance of Commercial And Residential Property Investments in Onitsha Metropolis, Anambra State, Nigeria. *British Journal of Earth Sciences Research*, *6*(2), 21–32.

Udoekanem, N., Ighalo, J., & Sanusi, Y. (2015). Predictive Modeling Of Office Rent In Selected Districts Of Abuja, Nigeria. *Real Estate Management and Valuation*, *23*(4), 95–104. https://doi.org/10.1515/remav-2015-0040

Udoekanem, N B, Ighalo, J. I., Sanusi, Y. A., & Nuhu, M. B. (2015). Office Rental Determinants in WUSE Commercial District of Abuja, Nigeria. *University of Mauritius Research Journal*, *21*(0), 2001–2012.

Udoekanem, Namnso Bassey, Ighalo, J. I., & Nuhu, M. B. (2014). Determinants of Commercial Property Rental Growth in Minna, Nigeria. *EUL Journal of Social Sciences*, *1*(June).

Ugwu, A. (2018). A Comparative Analysis of Rental Variation in Residential and Commercial Properties in Nigeria. *Afribary.Com (2018). Accessed April 02, 2021. Https://Afribary.Com/Works/a-Comparatuve-Analysis-of-Rental-Variation-in-Residential-and-Commercial-Properties-in-Nigeria-8947*.

USTAOĞLU, E. (2003). *Hedonic price analysis of office rents: a Case Study of the Office Market in Ankara*. *September*.

Von Thünen, H. J., Wartenberg, C. M., & Hall, P. (1966). *Von Thünen's isolated State.pdf*. Oxford London Edinburgh Frankfurt [u.a.] Pergamon Press 1966.

Wahab, M. B., Morenikeji, G. B., & Adeogun, A. S. (2017). Risk-return Performance of Residential Property Investment in Abuja, Nigeria. *ATBU Journal of Environmental Technology*, *10*(1), 95–108.

Yusoff, W. Z. W., Juanil, D. M., Alias, A., & Ali, A. S. (2010). A study of return on investment for commercial property in Johore State, Malaysia. *COBRA 2010 - Construction, Building and Real Estate Research Conference of the Royal Institution of Chartered Surveyors*, *January*.

Real Property Management in the Era of COVID-19 Pandemic in Nigeria: Promoting Real Estate Investment Trust as an Investment Vehicle

Bokani, A.M[1], Ahmed, M.[2] and Suleiman, Y. B.[3]
[1]Department of Private Law, Faculty of Law, Ahmadu Bello University, Zaria
[2] Umar Musa Yar'adua University, Katsina,
[3] *Fati Lami Abubakar Institute of Legal and Administrative Studies, Minna*
[1]Ambokani@abu.edu.ng; [2]Umeetamahuta@gmail.com; [3]Yatifi82@gmail.com
Corresponding author:Ambokani@abu.edu.ng

***Abstract**:*

There are two major ways through which investors can invest in real estate. The first way is purchase of real estate directly through vendors. The second involves the purchase of securitized real estate through shares, and this is illustrated by Real Estate Investment Trust ('REIT'). REIT is an investment vehicle which provides opportunities for investors to enjoy the advantages of investing in real estate at minimal cost. It concentrates its assets in real estate, and distributes income or dividends from rents and profits on investment to shareholders. Thus, the aim of this research is to examine REIT as an alternative method of managing real property in the era of Covid-19 pandemic. However, REITs are faced with some legal challenges which result to under performance of REITs in Nigeria. What then are the legal impediments and challenges to the operation of REITs in Nigeria? The objective of this research is to answer this question and proffer solution to the legal challenges while adopting the doctrinal research methodology. This paper argues that REIT offers a formidable real property management model in the era of Covid-19 pandemic in Nigeria. More so, it is also argued that there is no adequate and comprehensive legal framework for regulation and promotion of REIT in Nigeria. It is thus recommended that there is urgent need for legislation to be enacted specifically for regulation and promotion of REIT, and existing laws that undermine the operation of REITs should be amended to unlock the potential of REITs in Nigeria.

***Keywords:** Real Estate, Real Estate Investment Trust, Collective Investment Scheme, Collective Investment, Securities.*

Introduction

The concept of Real Estate Investment Trusts (REITs) is an investment vehicle which was inspired by the institution of trust. Although the idea of Trust developed as a means of providing support for the family, it has advanced into the commercial market as a vehicle for investment in real estate.[1]There are two major ways in which investors can invest in real estate. The first method is by purchase of real estate directly through vendors or property companies. This is the most common method of investing in real property whereby individuals buy property directly with cash or indirectly with equity funds and get freehold or leasehold title.[2] These individual owners invest capital, and take on significant risks, including those associated with construction, political, financial and business risks. The second method involves the purchase of securitized real estate or equity real estate investment trusts.[3] This method has become common as indirect investment opportunities now underscore the significance of Real Estate Investment Trust (REIT).

[1] Martin, E. (2001) *Modern Equity*. 6th Edition, Sweet & Maxwell Ltd, p 41.

[2] Uchenna, E and Kalu, I. U. (2016) 'Views on Real Estate Investment Financing in Nigeria'. *Journal of Economics and International Business Management*, Vol.4,No. p.30.

[3] Michael, J. S et al, (2001) 'Can Private Real Estate Portfolio Be Balanced /Diversified Using Equity REIT Shares?' *Journal of Real Estate Portfolio Management*, Vol.7,No. 1, p. 25.

Unfortunately, the huge interest rate of commercial banks is a turn-off to most developers. Thus, the real estate investors appear to be unable to effectively compete with other investment opportunities such as Capital market due to its capital-intensive nature, low yield, and long payback period. Consequently, the conventional methods of financing real estate are inadequate. This failure of the conventional sources to provide financing for real estate development created the need for alternative sources of financing.[4] The question therefore is why the REITs industry in Nigeria is not as productive and profitable as REITs in other countries? The objective of this paper is to appraise the legal framework for the regulation of REITs in Nigeria, highlight the challenges affecting the performance of REITs in Nigeria, and proffer solution to the research problem.

MEANING AND NATURE OF REAL ESTATE INVESTMENT TRUST

The REIT actually has its genesis in business trust which is a form of association based on the equitable trust, [5]and it is essentially an arrangement whereby property is conveyed to trustees, in accordance with the terms of a trust instrument to be held for the benefit of the holder of transferable certificate representing the share into which the beneficial interest in the property is divided.[6]One of the purposes for which trust device has been deployed is business investment which is the underlying idea of REIT.[7] REITs are constituted to own, and in most cases, manage and lease income- producing real estate such as apartments, shopping centres, offices, hostels, hotels, health facilities, industrial facilities, infrastructure and warehouses, for the benefit of investors as beneficiaries.[8]

REIT has been defined as a Collective Investment Scheme (CIS) that enables investors to pool their resources to with the objective to form, own and manage portfolios of real estate properties.[9] This definition however does not determine the type of interest investors can acquire, and how the company will raise funds for real estate development. A different definition of REIT is that it is a company that invests in and manages a portfolio of real estate, with the majority of trust's income distributed to its shareholders.[10]Unfortunately, this definition is not comprehensive because it does not represent the nature of Nigerian REIT as a collective investment scheme. Fortunately, the Investment and Securities Act defined REITs as "a body corporate incorporated for the sole purpose of acquiring intermediate or long-term interests in real estate or property development through the issuance of securities in the capital market.[11] This simple but comprehensive definition explains the nature of REIT as investment vehicle which enables investors to pool resources together, and acquire shares in real estate without directly owning real estate.

---

[4] Ajibola, M.O. et al. (2009) 'Real Estate Investment Trust: An Attractive Investment Vehicle for Real Estate Development in Nigeria' *Journal of the Nigerian Institute of Estate Surveyors and Valuers*, Vol.32, (1) p.62.

[5] W.E.N, (1962) 'The Real Estate Investment Trust in Multistate Activity.' *Virginia Law Review*, Vol.48 (6) p.1125.

[6] (f.n,5)

[7] Guobadia, D(1992) 'The Creation, Operation and Regulation of Units Trusts' In: Akank, E.O.(ed.) *Essays on Company Law*. Department of Commercial and Industrial Law, University of Lagos, p.313.

[8] O'Neal, N.C (2009) The Development of Islamic Finance in America: the Future of Islamic Real Estate Investment Trusts. Real Property, Trust and Estate Law Journal American Bar Association, Vol. 44,No. 2, p. 281.

[9] Rowh, M. (2003) *Careers in Real Estate*. McGraw-Hill, 2003), p.63.

[10] Garner, B.A. (2014) *Black's Law Dictionary.* 10th edition, Thomson Reuters, p.1455.

[11] Section 193 (1) of the Investment and Securities Act 2007.

The major characteristic of a REIT is that it is an innovation of tax law.[12] This means that so long as a REIT distributes at least 90% of its ordinary taxable income and meet other requirements of the law, it will not be taxed on that portion of its income which is accordingly distributed.[13] Thus, REITs enjoy a special 'tax status' and they are able to avoid taxation if they are able to meet certain regulatory requirements regarding the organization, operation and distribution of income generated from rents or sale of the properties.[14] However, REIT regulations globally have undergone numerous changes that have dramatically affected the growth of the industry. Real estate is an important portfolio of many institutional as well as individual investors. Because of some special features of real assets like lack of liquidity, lack of efficiency, lack of relevant performance measurements as well as high capitalization, private investors are limited in real estate direct investment.[15] These factors discourage many investors from participating in the ownership of large commercial real estate. Therefore, it has been argued that a possible solution is to create alternative forms of indirect real estate investments in the form real estate investment trust.[16]

To facilitate private and institutional investment, numerous countries have created special tax regimes for property companies in the form of REITs so as to avoid double taxation, and to create a level playing field between the different forms of real estate investment. A good example is the Finance Act[17] in Nigeria that has provided certain tax reliefs for REIT. The essence of the tax regime is to avoid taxing a rental income stream at the corporate level and again at the shareholder level.[18]REIT corporate structure enables qualified REITs to be able to avoid taxation at the corporate level provided they meet certain regulatory requirements prescribed by law.[19]Thus, exemption from the tax for a real estate company puts the investor in such a company in a favourable position as an investor who outrightly owns a real estate portfolio since the rental stream for such investor will only be taxed as income.[20] If a REIT meets all the statutory requirements, it will not be subjected to taxation on any of its capital gains or ordinary income which it distributes to its shareholders.[21]

In the United States and Nigeria, REITs are classified into three categories;[22] equity REITs, Mortgage REIT and Hybrid REITs. Equity REITs own income- producing real estate and seek to make profit by managing and selling real estate, improving existing properties and purchasing additional

[12] Aldrich, K.C, (192) 'Real Estate Investment Trusts: An Overview. *The Business Lawyer*, (27) (4) p.1165.

[13] (f.n,12)

[14] Penz, et al. (2011)'An Overview of Equity Real Estate Investment Trustee (REITs): 1993-2009 *Journal of Real Estate Literature,(19(2) American Real Estate Society*, p.307.

[15] Mazurczak, A. 'Development Real Estate Investment Trust (REIT) Regimes in Europe. (2011)(4)(1) *Journal of International Studies*, p.115.

[16] (f.n,15)

[17] Finance Act, 2020.

[18] (f,n 15) pp.115-116.

[19] Feng, Z. et al. (2011) 'An Overview of Equity Real Estate Investment Trust (REITS) 1993-2009' *Journal of Real Estate Literature,*Vol.10, (2)p.1.

[20] (f.n,15,) at p.116.

[21] Marvin S. Kahn, (1962) 'Taxation of Real Estate Investment Trusts.' (48)(6) *Virginia Law Review*, Vol. 48(6), p.1015.

[22] Kruger- Levy, N. and Bertoldi, A. *Residential REITs and their Potential Top Increase Investment and Access to Affordable Housing in Africa*. Centre for Affordable Housing Finance in Africa, p.30.

properties.[23]Equity REITs can be fully integrated real estate operating companies or may be focused on a specific aspect of real estate operations. Their operations generally include; acquisition and sale of properties, property management and leasing, property rehabilitation and repositioning and/or property development.[24]Mortgage REITs provide finance to real estate owners and operators either directly through mortgages or loans that are secured by real estate or indirectly through the purchase of mortgage backed securities.[25] That is, they lend money to investors, and invest indirectly through acquisition of loans or mortgage- backed securities .[26] Mortgage backed securities are publicly traded assets backed securities that are secured by a mortgage or a collection of mortgages and receive cash flows from the underlying pool of mortgages owned.[27] Mortgage REITs do not purchase, own or manage properties but invest in mortgages on real estate properties. Though these properties serve as collateral for the loans the mortgage REIT invests in, the REIT has no ownership position in the property itself.[28] However, Hybrid REITs are mixture of the Equity REITs and Mortgage REITs, and they generally participate in the real estate development and money lending and taking percentage of ownership.[29] Hybrid REIT benefits from the higher income potential of mortgage REITs and the stability of equity REITs.[30]

However, it is difficult to understand the legal basis of the classification of REITs into Equity, Mortgage, and Hybrid REITs in Nigeria. The Investment and Securities Act which regulate REITs in Nigeria recognises three types of collective investment Schemes which include Unit trust scheme, Open-ended Investment Company, and REIT.[31] Thus, the provision of the ISA and SEC Rules are silent on the aforementioned types of REIT which can be registered under the Act by SEC.[32] Therefore, it is arguable that these classifications of REITs are without legal basis and the classification suggests that there are different regulations for different categories of REITs. Nevertheless, the SEC Rules provide that a Real Estate Investment Scheme may be constituted as a company; a trust or such other structure as SEC may approve.[33] These conditions qualify a Collective Investment Scheme as a REIT in Nigeria and fulfilment of the conditions qualify the scheme for registration by SEC. However, if a REIT fails to meet these conditions after registration, it is liable to be de-registered by SEC. more so, it will not enjoy the special 'tax status' which affords it certain tax exemptions.

---

[23] McClellan, J.N. (2018) The Basics of Real Estate Investment Trusts (REITs) *American Association of Individual Investors Journal*, Michigan Are., p.8.

[24] (f.n,23) p.8.

[25] (f.n, 23) p. 8.

[26] Mozurczak, A. 'Development Real Estate Investment Trust (REIT) Regime in Europe. (2011) (1) *Journal of International Studies*, p.118.

[27] (f.n, 26)

[28] <Http://www.nse.com.ng/products/equities/reits> Accessed on 13th August, 2020 at 1:08pm.

[29] Cummings, J,(2008) *Real Estate Finance and Investment Manual*. 9th edition, John Wiley & Sons, Inc., p.118.

[30] (f,n 29) p.63.

[31] Section 154(1)(a)(b)(c) of ISA,2007.

[32] ISA, Section 195(1) of ISA, 2007.

[33]Rule 508 of SEC Rules. <Http://sec.gov.ng/wp-content/uploads/2017/07/June-2017-SEC-Executed-Rules.doc&ved=2ahUKEwiUkLDDy93xAhUR6OAKHbyDDZQQFjAAegQIChAB&usg=AOvVaw3D-ls6xc4c45tiZIeWgN4Z> Accessed 12th July, 2021 at 4:00pm.

RULES GOVERNING REAL ESTATE INVESTMENT TRUSTS IN NIGERIA

In Nigeria, there are laws which regulate REITs but the two main statutes are the Investment and Securities Act and Companies and Allied Matters Act[34]. The Land Use Act has been described as the most impactful of all legislation touching on the land tenurial system in the country and a legal regime which revolutionized the interests of Nigerians by expropriation.[35] Other relevant laws include the Capital Gains Tax Act, which makes every gain on property a chargeable gain; Land Instrument Registration Act and Laws of various States; Conveyancing Act; Property and Conveyancing Laws, and Stamp Duties Act which are all relevant to real estate development and investment.[36] The idea underlying these laws is the right of persons (individual and corporate entities) to acquire, and invest in immovable property in Nigeria.[37] REITs as defined by ISA does not include a Collective Investment Scheme permitted by any other Act.[38] Orojo opined that before the enactment of the Companies and Allied Matters Act (CAMA), no special provisions were made for Collective Investment Schemes, and thus it was CAMA that made adequate provisions for the Unit Trust Schemes.[39] Subsequently, the Investment and Securities Act recognised Unit Trust Scheme and other forms of Collective Investment Scheme.[40] Orojo (2008) noted that ISA dealt almost exclusively with the unit trust scheme and other Collective Investment Scheme.[41]

There are three types of Collective Investment Schemes permitted in Nigeria: the Unit Trust Scheme, Open- ended Investment Company and Real Estate Investment Company or Trust.[42] The Unit Trust Scheme is an arrangement in which participants pool resources for the purposes of sharing profits or income arising from the management of their money or property solely from the efforts of a third party.[43] Advantages provided by the Unit Trust Scheme is to assist, encourage, and promote investors' participation in the capital market with little fund while enjoying the benefit of risk diversification, professional management, liquidity capital appreciation and earning through dividends payment.[44] However, REIT can only be registered if it complies with certain requirements of the law.[45] First, it must be incorporated under Companies and Allied Matters, after fulfilling the requirement for registration of companies.[46] Consequently, the subscriber of the memorandum together with other members shall be a body corporate by the name contained in the memorandum.[47] It must also have

---

[34] CAMA, 2020.

[35] Grace, O.A, 'Interrogating The Challenges of Real Estate Development and Secured Credit Financing in Nigeria, (2019)(6) *Journal of Commercial and Property Law*, Department of Commercial and Property Law, 99-100.

[36] Ibid, p.100.

[37] CFRN, 1999, s44.

[38] ISA,2007, s 153(1)(a)(b)

[39] Orojo, O.J, (2008) *Company Law and Practice in Nigeria.* 5th Edition, LexisNexis, p.413.

[40] ISA, 1999, s 125-145.

[41] Orojo, J.O. Op. Cit. p. 412.

[42] Section 154 (1) (a)(b)(c) of ISA, 2007.

[43] Apinega, S.A. (2003-2005) 'Annotation to Unit Trust Scheme Provisions under the Nigerian Investments and Securities Act, 1999' (2) (1) *Journal of Commercial Law*, Vol.2(1)Department of Commercial Law, Faculty of Law, ABU, Zaria, p.66.

[44] (f.n,52) at 68.

[45] CAMA, 2020; ISA, 2007.

[46] Sections 36,37,39,40, & 41 of ZCAMA,2020.

[47] Section 42 of CAMA, 2020.

capital and reserve as SEC may prescribe from time to time; it must carry on business as a collective investment Scheme; and it must comply with requirements prescribed by the Commission in its Rules and Regulations. SEC provides the regulatory framework for operation of REITs in Nigeria. The SEC is a forum for medium to long term development finance.[48] It is empowered to approve, register and regulate REITs in Nigeria.[49] The SEC Rules and Regulations, 2011, contain both rules of general and specific applications governing the operation of collective investment schemes in Nigeria pursuant to Section 313 of the Investment and Securities Act.[50] However, the Rule does not define the scope of the duties of a Manager of a REIT who acts as a trustee for the shareholders. Thus, the pertinent question is, what constitutes standard of the duty of 'honesty', 'fairness', 'skill', 'care' and 'diligence required of the Manager as defined in section 155 of the Act[51]? It is submitted that this duty is similar to the general duty of the trustee in equity, and the standard of the duty is that of a professional manager. Under section 155 of the Act therefore, the Manager is required to exhibit high degree of honesty, care, skill, and diligence expected of a specialist in REIT management.[52]

One of the legal processes for regulation of the capital market by the SEC is through registration of capital market operators. It is the most potent tool for REIT regulation by SEC.[53] For a REIT to be registered by SEC, it must meet the following requirements: it must be incorporated[54]; it must have capital and reserves as prescribed by the Securities & Exchange Commission, it must carry on business as a Collective Investment Scheme solely in real properties[55], and comply with certain requirements prescribed by the Commission through its Rules and regulations.[56]The Rules and regulations governing the operation of the REITs in Nigeria are outlined in the Securities and Exchange Commission Rules and Regulation, 2013 and its amendments.[57] It is important to note that REITs in Nigeria are subject to tax laws as they are still required to pay Companies Income Tax (CIT) at the rate of 30%.[58] The Companies Income Tax Act does not provide incentive or relief for REIT.[59]However, certain other tax

---

[48] Agom, A.R. (2016-2017) 'Investment and Securities Tribunal: A Veritable Tool for Development and Growth in the Nigerian Capital Market, (8)(1) *Journal of Commercial Law*,Vol.8(1), Faculty of Law, Ahmadu Bello University, Zaria, p.63.

[49] Section 154 of the Investment and Securities Act, 2007.

[50] Herein after referred to as ISA

[51] ISA, 2007.

[52] Ezejoifor, G,(2004) 'Appointment, Powers, and Duties of Trustees' in Utuama, A.A. and Ibru, G.M (eds.) *The Law of Trusts and their Uses in Nigeria*. Malthouse Press Limited, p.19.

[53] Akume, A.A. (2006-2007) Critical Analysis of the Exercise of the Securities and Exchange Commission's Powers to regulate the Nigerian Capital Market. *Journal of Commercial Law*, Vol.3(1)Department of Commercial Law, p.195.

[54] Companies and Allied Matters Act, 2020.

[55] Section 193 of ISA, 2007.

[56] Section 194 of ISA.

[57] Kruger- Levy, N. and Bertoldi, A. (2017) *Residential REITs and their Potential Top Increase Investment and Access to Affordable Housing in Africa*. Centre for Affordable Housing Finance in Africa, p.30. < www.housingfinanceaferica.org/ appleploads/cahf-real-estate-investment-first-study-2017.02. Pdf> Accessed on 17/15/2020 at 1:18pm.

[58] Companies Income Tax Act, Cap.C21, LFN, 2004, s 40.

[59] Abdulrazaq, M.T. (2010) *Revenue Law and Practice in Nigeria*, Malthouse Press Limited, Lagos, 180.

exemptions exist such as tax waiver on assets and mortgage backed securities.[60] Additionally, the dividends of publicly traded REITs are exempted from Withholding Taxes (WHT) in the hands of the investors.[61] Value Added Tax (VAT) and Capital Gain Tax (CGT) on sales of these units or securities are also not applicable.[62]Under the Companies Income Tax Act, REITs are treated as Companies and unit holders as shareholders while the profits earned by collective investments schemes are subject to Company Income Tax of 30%.[63] This provision is questionable because REIT is a mere vehicle by which income obtained from investment in real estate is distributed to shareholders and thus only the investors should be taxed. However, REIT may be eligible for the government's grant of pioneer status incentives which are company tax holidays of three-Five years, under the recent pioneer status guidelines. More so, REITs in Nigeria enjoy tax exemption under the Companies Income Tax Act provided they fulfil the following conditions: 1. Minimum of 75% percent of dividend and rental income is distributed to shareholders and 2. Distribution of dividend or income is made within 12 months of the end of the financial year in which the dividend or rental income was earned.[64] Fulfilment of these conditions entitle REITs to tax exemption, and failure to fulfil both or any conditions will attract tax to be paid on the dividends or rental income received by the REITs on behalf of the shareholders. The Finance Act[65] seems to have adopted the conditions stipulated in the SEC Rules, 2017 with minor modifications. While the Rules provide that dividends shall be distributed annually,[66] the Finance Act is more specific that such distribution of dividends must be made within 12 months of the financial year in which the income or dividend was earned.

It may however be argued that the conditions stipulated by SEC Rules[67] regulate REITs in the capital market while the conditions in the Finance Act apply when tax reliefs for REITs are being considered. The Finance Minister noted that the philosophy behind the reliefs to REIT is to reward the investors for fulfilling their promises by actually investing in real estate, and not to reward investors for mere intention to invest.[68] The relief will be granted where the regulatory body is satisfied that specific investments have been made in the real estate. However, investors in REITs are not exempted from tax on the dividend or rental income received from REITs. Therefore, they are required to pay tax on the dividends received from the REITs.[69] Similarly, REITs are also required to pay tax on the management fees, profits or any other income earned by the company on its own account.[70] REITs are empowered to raise funds from capital market through the issuance of securities with specific advantages to the investor such as a right to a share of the income of any property and voting rights in the management of the company.[71] These are some of the rights of a shareholder or investor in a REIT in Nigeria. The law

---

[60] Kruger- Levy, N. and Bertoldi, A, 31.

[61] (f.n, 60)

[62] (f.n,60)

[63] Section 23 of CITA, 2004.

[64] CITA, 2004, s 23 (1)(s) amended by Finance Act, s 10. 2020 published in the Federal Republic of Nigeria Official Gazette, Vol.107, No.6, 14th January, 2020.

[65] CITA, s 23(1) (s) as amended by section 9 of Finance Act, 2019.

[66] Rule 510 of SEC Rules, 2017.

[67] (f.n,66)

[68] <https://www.youtube.com/watch?v=auceOCR9Rak&t=94s>. Accessed on 13/7/2021 at 12:00pm

[69] CITA, s 23(1B)a of the as amended by Section 9 of the Finance Act, 2019.

[70] CITA, Section 23(1B)b as amended by Section 9 of the Finance Act, 2019.

[71] Keke, O.V and Emoh, F.I, 'Real Estate Investment Trust (REITs) and Mortgage Backed Securities (MBS) as

permits the REIT to invest its funds in accordance with the provisions of the trust deed or custodial agreement and in investing the funds, it is required to do so in accordance with the provisions of the Act.[72]

The above are therefore investments that the assets and funds of a REIT can be invested into apart from real estate which will ensure fair returns on investment. This list is not exhaustive as the SEC has power to prescribe instruments which a REIT can invest into.[73] For the purpose of complying with the guideline as to the quality of instruments that the REIT can invest into, the manager considers the risk rating of instruments that has been undertaken by a rating company registered under ISA.[74]However, the instruments provided by the ISA are subject to the guidelines issued by the SEC from time to time. It is difficult to understand why the express provisions of the Act will be made subject to the guidelines to be issued by SEC. The implication is that the guidelines issued by SEC supersede the provisions of the Act on the instrument's REITs can invest into. In any case, the fund of the REIT shall be invested in accordance with the provisions of the Trust deed or custodial agreement. SEC issued the first set of registration and operation requirements and guidelines which culminated into the first two REITs in Nigeria,[75] and these followed the enactment of ISA[76]. Rules 250- 281 of the SEC Rules which provide for Real Estate Investment Schemes (REIS) were made pursuant to the SEC Rules and Regulations.[77] The SEC Rules, 2013 did not take into cognisance the Real Estate Investment Company or trust provided for under Section 193 of the ISA.[78] However, subsequent amendment of the SEC Rules and Regulations made ample provisions for Rules regulating REITs in Nigeria. [79]The underlying idea behind the SEC Rules and Regulations is that members of the public and investors who are offered company securities are entitled to full disclosure of the nature of the offer before they make financial commitment, and to remedies to redress loss suffered arising from failure on the part of the company to make complete and accurate disclosure.[80]

CHALLENGES FACING REAL ESTATE INVESTMENT TRUSTS IN NIGERIA.

Certain factors and challenges account for poor performance of REITs in Nigeria. The major challenge which has been identified is lack of access to finance. It has been observed that real estate is a capital-intensive investment and developers often face challenge in accessing finance to complete their

Emerging Trends for Financing Real Estate Development in the Nigerian Capital Market. (2015)(3)(2) *International Journal of Civil Engineering, Constructive and Estate Management*, p.2.

[72] Section 171(1) (2) of ISA, 2007.

[73] Section 171(3) (4) of the ISA, 2007.

[74] Section 171 (5) of the ISA, 2007.

[75] Olanrele, O.O et al., (2015) 'Comparison of REIT Dividend Performance in Nigeria and Malaysia.' *African Journals Business Management*, Vol.9 (6),p. 609.

[76] Olanrele, O.O et al,(2015) 'An Evaluation of the Performance and Acceptability of REIT in Nigeria.' Paper Presented at 15th Afres Annual Conference, p271.

[77] SEC Rules and Regulations Amendments, 2006(2)

[78] Fund Managers Associated of Nigeria. (2017), *5- Year Strategic Master Plan and Roadmap (2013- 2018)*, p.22. < www.sec.gov.ngs>uploads 2012/02>. Accessed on 14th June, 2021 at 5:40pm.

[79] Davies, P.L. (1997) *Gower's Principles of Modern Company Law*. 6th edition, Sweet& Maxwell, London, p.394.

[80] (f.n,79) p. 394.

development process.[81] Real estate financing requires huge capital and is always a challenge for investors who are charged high- interest rates with cumbersome repayment conditions.[82] Nigerian Bank Lending rate was reported at 11.240% pa in April, 2021 which represents an increase from the previous number of 11.130 % pa in March, 2021[83], and in September, 2022, it was increased to 15.5%.[84]This has negatively affected access to finance by investors who want to invest in real estate market. In fact, finance has been described as a major challenge to real estate development in Nigeria because critical components of REIT involve infrastructural development such as good road network, and social amenities.[85]Thus, financial strategies have become efficient process for providing real estate developers/ investors with the necessary financial proficiency to actualize the proposed development and enhance their operation.[86] The ability of a developer to mobilize enough funds for the project determines largely the success of the project.[87]The performance of real estate investment financing will depend primarily on the volume and nature of funds within the economy and the proportion of it to be spread, mobilised or even dedicated for housing.[88] In many parts of the world, especially the developed countries, the source of housing finance is from government, individual savings, life insurance reserves, commercial banks, savings and loan institutions.[89] In Nigeria, the main sources of housing finance are government by way of loan and grants.[90] Thus, one of the challenges of REIT is the poor availability/ accessibility of low credit facilities.[91]

The second challenge is the inaccessibility of land for real estate development. For REIT, the need for availability and access to land for development cannot be over emphasised. By the provision of the SEC Rules, *"a Real Estate Investment Trust can and shall wholly acquire and hold legal title to property or choose to hold equitable and beneficial title to such property vide a Trust Deed or such other structure*

---

[81] Olayinka, C.O et al. (2017) 'Problems and Prospects of Forward Sale in the Nigerian Housing Market: A Critique of Policy and Modus Operandi'*International Journal of Academic Research in Business and Social Science*, Vol.7(4) p.547.

[82] Uchenna, E. and Kalu, I.U. Op. Cit p. 30.

[83] < https://www.ceicdata.com/en/indicator/nigeria/bank-lending-rate> Accessed on 20/6/2021 at 1:45pm.

[84] < https://www.vanguardngr.com/2022/09/cbn-raises-interest-rate-to-15-5/> Accessed on 23/11/2022 at 11:09am.

[85] Ezimuo,P.N. et al. (2014) 'Sources of Real Estate Financing and their Impact on Property Development in Nigeria: A Case Study of Mortgage Institutions in Lagos Metropolis', *British Journal of Environmental Research,* Vol.2 (2) p.35.

[86] (f.n,85).

[87] Ogedengbe, P.S. and Adesope, A.A. 2003) '*Problem of Financing Real Estate Development in Nigeria*. J. Hum. Ecol., Vol.14(6), p.426.

[88] (f.n,87) p. 426.

[89] Ayedun, C.A. and Oluwatobi, A.O. (2011) 'Issues and Challenges Militating Against the Sustainability of Affordable Housing Provision in Nigeria.'*Business Management Dynamics,* Vol.1(4) p. 4.

[90] (f.n,89) p.4.

[91] Mubor, P.K. (2017) Challenges of Housing Finance and Its Implications on Home Ownership by the Low and Modern Income Earners in Nigeria (A Case Study of Port Harcourt, Rivers State) *Journal of Environmental Service, Toxicology and Food Technology*, (11)(6) Vol. 80.

as may be acceptable to SEC".[92] This provision underscores the importance of land to operation of REIT, and the need for REIT to acquire land for development and investment. However, Land acquisition for development in Nigeria is characterised by title registration which goes through arduous processes of documentation. Thus, the strict provisions on consent of the Governor and administrative bottlenecks have made it difficult for Nigerians who cannot get allocation from government to acquire same from individuals.[93] More so, cost of registration of title especially when there is change of ownership is high which may discourage investors in real estate development.[94] For example, the Managing Director of UBN properties disclosed that while applying for the planning approval for a piece of land which his company acquired at Lekki phase1, Lagos State government demanded N16,000,000.00 after which he was asked to go to the New Town Development Authority for clearance.[95]

Third critical challenge to REIT in Nigeria is the deplorable state of infrastructure.[96] It is the responsibility of government to provide infrastructure and basic amenities to the people which will in turn attract investment, especially in the real estate sector. Unfortunately, Nigeria has huge infrastructural deficit and this makes investment in the real estate sector difficult and unattractive because the real estate investment is capital intensive. Infrastructure like roads network, electricity supply, water, hospitals, and educational facilities are drivers of economic growth. The quality of infrastructure available within any environment plays an important role in attracting new investments.[97] Therefore, poor road networks and social amenities are facilities that REITs have to contend with to meet the demands and satisfaction of occupiers. In a study conducted on effect of poor road network on rental value of residential property values in Minna, Niger State it was found that the rental value in Tunga area was higher than Bosso area which is attributed to better state of infrastructure in Tunga area.[98] Finally, SEC is the apex body responsible for the regulation of the capital market, and investment and securities business in Nigeria.[99] One of the functions of the SEC is to promote education of the investors and training of all categories of intermediaries in the securities industry.[100]However, the level of awareness of benefits of REIT by investors has not been impressive. It has been observed that many individual investors are not aware of benefits of REITs as an investment option; even the few institutional investors who are knowledgeable about REITs still have a poor perception about it and are not generally ready to invest fully in the scheme. This has contributed to the underperformance of REITs. It can be submitted however that perhaps the law establishing REIT has not adequately empowered the function of SEC in regulating REIT in Nigeria.

---

[92] Rule 509(1).

[93] Madaki, A.M. and Magashi, S.B, Availability of Land to Every Nigerian under the Land Use Act: Rhetoric or Reality? (2018) (9) (2) *Journal of Private and Comparative Law*, Department of Private Law, ABU,Zaria,362.

[94] Ajibomi, M.O. et al, Op. Cit. (2009)63-64.

[95] Ogiji, L.O, 'The Land Use Act and the Challenge of Restraints in Transfer of Land Rights', (2015)(29-35) *Ahmadu Bello University Law Journal*,6.

[96] Kari, U. et al, 'The Challenges of Infrastructural Development in Nigeria: An Assessment of the Pains and Gains' (2019) (7)(4) *International Journal of Political Science and Development*,106.

[97] Orekan, A.A. (2015) 'The Impact of Infrastructural Facilities on Residential Property Development in Ota, Ogun State,' *Covenant Journal of Research in the Built Environment*, Vol.3(2),p.3.

[98] Ajayi, M.T.A. *et al.* (2014) 'Effects of Infrastructural Development on Residential Property Values in Minna' *Euthopian Journal of Environmental Studies and Management*, Vol.7 (4) p.458.

[99] ISA, 2007, s 13(a).

[100] (f.n,99), s 13(s).

CONCLUSION

Real Estate Investment Trust offers an alternative as a formidable investment vehicle in the real estate sector since its introduction in Nigeria. It is one of the investment vehicles driven by the principle of trust which provides opportunities for all categories of investors to enjoy the benefits and advantages of investing in real estate without financing the entire real estate development. However, it is a finding of this research that the classification of REITs into Equity, Mortgage, and Hybrid REITs in Nigeria is without legal basis because ISA does not classify REITs into these categories. More so, the Nigerian REITs are not performing well like REITs in other jurisdictions because of the numerous laws such as Land Use Act, ISA, CAMA, and Finance Act that negatively impact the REIT industry in Nigeria which have made it difficult for the industry to meet its expectation. This is evidenced by the absence of a comprehensive legislation that will regulate REITs in Nigeria to stimulate real estate development in Nigeria. It is thus recommended that there is need for government to take proactive steps to make REIT dominant vehicle for real estate ownership and real property financing in Nigeria. Therefore, government should enact a comprehensive legislation to provide the adequate legal framework for operation and regulation of REITs in Nigeria. Additionally, the Securities and Exchange Commission should be strengthened to provide the regulatory support to investors who are interested in the real estate sector. The Land Use Act should also be amended to make it easy and affordable for REITs to have access to land for development and obtain Governor's consent while stakeholders should be given more incentives to attract investment in the REITs industry.

REFERENCES

Abdulrazaq, M.T. (2010). *Revenue Law and Practice in Nigeria*, Malthouse Press Limited, Lagos.

Agom, A.R. (2016-2017). 'Investment and Securities Tribunal: A Veritable Tool for Development and Growth in the Nigerian Capital Market, (8)(1) *Journal of Commercial Law*, Vol.8(1), Faculty of Law, Ahmadu Bello University, Zaria.

Ajayi, M.T.A. *et al*. (2014) 'Effects of Infrastructural Development on Residential Property Values in Minna'. *Ethiopian Journal of Environmental Studies and Management*, Vol.7 (4).

Akume, A.A. (2006-2007). Critical Analysis of the Exercise of the Securities and Exchange Commission's Powers to regulate the Nigerian Capital Market. *Journal of Commercial Law*, Vol.3(1), Department of Commercial Law.

Aldrich, K.C. (1972). 'Real Estate Investment Trusts: An Overview. *The Business Lawyer*. Vol. 27 (4).

Apinega, S.A. (2003-2005). 'Annotation to Unit Trust Scheme Provisions under the Nigerian Investments and Securities Act, 1999' (2) (1) *Journal of Commercial Law*, Vol.2(1) Department of Commercial Law, Faculty of Law, ABU, Zaria, 66.

Ayedun, C.A. and Oluwatobi, A.O. (2011). 'Issues and Challenges Militating Against the Sustainability of Affordable Housing Provision in Nigeria.'*Business Management Dynamics*, Vol. 1 (4).

Cummings, J. (2008). *Real Estate Finance and Investment Manual*. 9th edition, John Wiley & Sons, Inc.

Davies, P.L. (1997). *Gower's Principles of Modern Company Law*. 6th Edition, Sweet& Maxwell, London.

Ezejoifor, G. (2004). 'Appointment, Powers, and Duties of Trustees' in Utuama, A.A. and Ibru, G.M (eds.) *The Law of Trusts and their Uses in Nigeria*. Malthouse Press Limited.

Ezimuo, P.N. et al. (2014). 'Sources of Real Estate Financing and their Impact on Property Development in Nigeria: A Case Study of Mortgage Institutions in Lagos Metropolis', *British Journal of Environmental Research*, Vol.2(2).

Feng, Z. *et al*. (2011). 'An Overview of Equity Real Estate Investment Trust (REITS) 1993-2009' *Journal of Real Estate Literature*, Vol.10, (2).

Garner, B.A. (2014) *Black's Law Dictionary*.10th Edition, Thomson Reuters.

Grace, O.A. (2019). 'Interrogating The Challenges of Real Estate Development and Secured Credit Financing in Nigeria, *Journal of Commercial and Property Law*, Vol.6, Department of Commercial and Property Law.

Guobadia, D. (1992). 'The Creation, Operation and Regulation of Units Trusts' In: Akank, E.O. (ed.) *Essays on Company Law*. Department of Commercial and Industrial Law, University of Lagos.

Helen, X.H.B, *et al*. (2015). 'Real Estate Investment Trust Returns: Predictability and Determent', *Journal of Real Estate Practice and Education*, Vol.18, No.1, American Real Estate Society.

Kari, U. *et al*. (2019) 'The Challenges of Infrastructural Development in Nigeria: An Assessment of the Pains and Gains' *International Journal of Political Science and Development*, Vol.7(4).

Keke, O.V and Emoh, F.I, (2015). 'Real Estate Investment Trust (REITs) and Mortgage-Backed Securities (MBS) as Emerging Trends for Financing Real Estate Development in the Nigerian Capital Market. *International Journal of Civil Engineering, Constructive and Estate Management*, Vol.3(2).

Madaki, A.M. and Magashi, S.B. (2018) Availability of Land to Every Nigerian under the Land Use Act: Rhetoric or Reality? *Journal of Private and Comparative Law*, Vol.9(2), Department of Private Law, ABU, Zaria.

Martin, E. (2001). *Modern Equity*. 6th Edition, Sweet & Maxwell Ltd.

Marvin S. Kahn, (1962). 'Taxation of Real Estate Investment Trusts.' (48)(6) *Virginia Law Review*, Vol. 48(6).

Mazurczak, A. (2011). 'Development of Real Estate Investment Trust (REIT) Regimes in Europe' (4)(1) *Journal of International Studies*, vol.4(3).

McClellan, J.N. (2018). The Basics of Real Estate Investment Trusts (REITs) *American Association of Individual Investors Journal*, Michigan Are.

Michael, J. S *et al*, (2001). 'Can Private Real Estate Portfolio Be Balanced /Diversified Using Equity REIT Shares?' *Journal of Real Estate Portfolio Management*, Vol.7, No. 1.

Mubor, P.K. (2017) Challenges of Housing Finance and Its Implications on Home Ownership by the Low- and Modern-Income Earners in Nigeria (A Case Study of Port Harcourt, Rivers State) *Journal of Environmental Service, Toxicology and Food Technology*, (11)(6) Vol. 80.

O'Neal, N.C. (2009). The Development of Islamic Finance in America: The Future of Islamic Real Estate Investment Trusts. Real Property, Trust and Estate Law Journal American Bar Association, Vol.44, No. 2.

Ogedengbe, P.S. and Adesope, A.A. 2003). 'Problem of Financing Real Estate Development in Nigeria'. *J. Hum. Ecol.*, Vol.14 (6).

Ogiji, L.O, (2015) 'The Land Use Act and the Challenge of Restraints in Transfer of Land Rights', *Ahmadu Bello University Law Journal*, Vol.29-35).

Olanrele, O.O *et al*, (2015). 'An Evaluation of the Performance and Acceptability of REIT in Nigeria.' Paper Presented at 15th Afres Annual Conference.

Olayinka, C.O *et al*. (2017). 'Problems and Prospects of Forward Sale in the Nigerian Housing Market: A Critique of Policy and Modus Operandi' *International Journal of Academic Research in Business and Social Science*, Vol.7 (4).

Orekan, A.A. (2015) 'The Impact of Infrastructural Facilities on Residential Property Development in Ota, Ogun State', *Covenant Journal of Research in the Built Environment*, Vol.3 (2).

Orojo, O.J, (2008). *Company Law and Practice in Nigeria.* 5th Edition, LexisNexis.

Penz, *et al*. (2011). 'An Overview of Equity Real Estate Investment Trustee (REITs): 1993-2009.*Journal of Real Estate Literature, (19(2) American Real Estate Society*.

Rowh, M. (2003). *Careers in Real Estate*. McGraw-Hill.

Uchenna, E and Kalu, I. U. (2016). 'Views on Real Estate Investment Financing in Nigeria'. *Journal of Economics and International Business Management,* Vol.4, No.

Assessment of Property Management Practices During and After Covid-19 Pandemic in Lagos, Nigeria

Ogungbe, M.A.[1a], Jejelola, O.F.[1b] & Akinwamide, D.O[2]

[1]*Department of Estate Management, Adekunle Ajasin University, Akungba-Akoko, Ondo State, Nigeria*

[2]*Department of Estate Management and Valuation, Auchi Polytechnic, Auchi, Edo State, Nigeria*

ogungbemayowa@yahoo.com; oluwatofunmidavid@gmail.com

Corresponding email: ogungbemayowa@yahoo.com

Abstract:

The 2019 Coronavirus Disease (COVID-19) pandemic, which started as a health crisis, is now quickly evolving into a crisis in the real estate industry, including property management. This pandemic is anticipated to have a greater impact on property management jobs that require regular interaction with people (such as landlords, clients, tenants, and maintenance staff). This claim calls for an evaluation of property management procedures during, and after the Covid-19 Pandemic in Lagos State, Nigeria. Every other member of the Nigerian Institution of Estate Surveyors and Valuers directory was chosen using a systematic random sampling technique, giving a sample size of 176 estate surveying and valuation firms. The questionnaires were written using a five-point Likert scale. But 155 responders were considered to be legitimate responses. Both descriptive and inferential analyses were used to analyse the acquired data. The study evaluated property management procedures before and after the COVID-19 pandemic in Lagos State, Nigeria using the Weighted Mean Score and the Wilcoxon Signed-Rank Test. In accordance with the agreed-upon critical p-value of 0.05 (significant level), the Wilcoxon Signed-Rank Test revealed that all 22 of the variables taken into consideration, with the exception of one, were statistically significant. This revealed a statistically significant difference between property management practices before and after the Covid-19 pandemic. Among other things, it was advised that strict adherence be given to all Covid-19 measures relating to property management procedures because the coronavirus is still very much alive and well. If all these measures are followed, stakeholders will find this paper as a useful tool for effective property management practices.

***Keywords**: Assessment, Covid-19, Pandemic, Property Management, Lagos.*

Introduction

Property management is understood to be the systematic supervision and regulation of real estate investments with the goal of getting the best return, which may take the form of financial gain, reputational advantage, or social benefit. The management of rental property, such as apartments, residences, and office buildings, is also included. There is a written contract between a landlord or his representative and the people who utilize the property (otherwise known as tenants or occupiers).

Property management, according to (Cheng 1998; Tomori 2005), is "a series of straightforward procedures serving buildings, such as cleaning the common spaces, assigning security guards, and maintaining the common areas of building premises and services." Finding suitable tenants, collecting rent, maintaining the property to keep it in good condition, handling tenant complaints, paying bills (both statutory and commercial), ensuring value for money, keeping an eye on their belongings, and other duties are all part of the profession of property management.

Property management is defined as the physical, administrative, or financial upkeep and management of real estate, or the supervision of such activities for a fee, commission, or other compensation or valuable consideration, pursuant to a property management agreement (by the Nevada State Real Estate Division 2008). It is the process of managing real estate that is up for rent by keeping up with and taking care of all the regular activities focused on the piece of property. Property management procedures are expected to be more impacted by the COVID-19 pandemic because they entail frequent contact with humans (landlords, clients, tenants, and maintenance personnel). The World Health Organization (WHO) proclaimed a pandemic of the Coronavirus Disease-2019 (COVID-19) on March 11, 2020. (World Health Organization, 2020a). With cases recorded from every African nation, the epidemic is now firmly entrenched there. However, Nigeria filed her first case on February 27, 2020, in Lagos (NCDC 2020). The Federal Government implemented a Temporary shutdown and a Work from Home Arrangement in order to stop the spread of COVID-19 and protect employees and members of the public.

According to Oladokun (2010), sustainable property management is still a relatively new practice in Nigeria. Therefore, the examination of property management practice during this period of the COVID-19 epidemic is of great concern. In light of this, the goal of this study is to evaluate property management procedures before, during, and after the COVID-19 epidemic in order to provide advice to property managers on the best procedures.

Literature Review

Overview of Property Management Practice

An Estate Surveyor and Valuer's expertise in the use, development, and administration of land and property comes from his training in finance, economics, accounting, architecture, quantity surveying, land law, and computer science. Property management is a broad field that calls for the use of expertise and knowledge to unlock the "latent values" of real estate assets. According to Oladokun (2010), it is the application of skill in the maintenance of a property, its surroundings, and amenities in order to create a solid relationship between a landlord and a tenant as well as between tenants, allowing the property to provide its full value to both the landlord and the owner. This definition was provided by Macey and Baker in 1978. It is a complicated task. In order to maximize return, it involves the management, nursing, and occasionally general direction of policy of an interest in landed property (Thorncroft 1976). The maximization of the owner's investment is the primary goal of property management (Scarrett, 1995). It is a deliberate process to direct and tailor a property investment into a successful venture.

Property management practices being a day-to-day activity involves coming in contact with people (landlord, client, tenants and maintenance workers), is likely to be more affected by Covid-19 pandemic. The Coronavirus Disease-2019 (COVID-19) was declared a pandemic by the World Health Organization (WHO) on 11th March 2020 (World Health Organization, 2020a). As of May 22, 2021, there were 166,511,629 people worldwide who had contracted the coronavirus disease 2019 (COVID-19) pandemic, which had also claimed 3,458,747 lives. Africa has now experienced a significant spread of the Covid-19 pandemic, with cases being reported from every nation there. It is important to note that professional practice around the world appears to be impacted by the impact of the covid -19 pandemic on their operations, notwithstanding the substantial progress that has been made in Nigeria in response to the pandemic. The Covid-19 pandemic has presented numerous obstacles to various professions around the globe, particularly during the lock down (Oyedeji, 2020) The covid-19 protocols such as working from home measures, social distancing, avoiding of crowd, use of face mask gave professional practitioners no other option than to device alternatives in carrying out their operations. To protect employees and members of the public from the spread of COVID-19, the Federal Government enacted a Temporary lockdown and a Work from Home Arrangement in order to reduce the spread of this pandemic.

According to the author's knowledge, no known study has yet evaluated the property management strategies used in Nigeria before, during, and after the COVID-19 outbreak. The research of Oyedeji (2020) and Zhanda (2020) is closely linked. When this study was critically analyzed, it became clear that no one had given the assessment component of property management practice during and after the COVID-19 pandemic any in-depth consideration. In the study by Oladokun (2010), Ogunba and Iroham (2005) make the argument that no profession in the built environment should be static or rigid lest it become out of date. It must draw lessons from the past, adjust to the shifting conditions of the present, and simultaneously foresee the requirements of succeeding generations. As a result, the covid-19 pandemic and the alleged countermeasures (partial or complete lockdown, working from home measures, social withdrawal, avoiding crowds, usage of face masks, etc.) are affecting every profession, and property management is not an exception in this regard.

Control Measures on COVID-19 Pandemic

According to The Federal Ministry of Health and the Nigerian Centre for Disease Control (NCDC, 2020) put in place some certain control measures and guidelines for prevention of COVID-19 pandemic. These measures include:

i. Regular hand washing with soap and water that is running for at least 20 seconds;

ii. the use of an alcohol-based hand sanitizer that contains at least 60% to 70% alcohol;

iii. the use of dettol and sodium hypochlorite (bleach) water to disinfect surfaces;

iv. the avoidance of touching the nose, eyes, and mouth with unwashed hands; the avoidance of close contact with people who are sick or have a fever and cough;

v. and the observation of a 2-meter physical distance between oneself and others as community transmission is fast.

Other measures applicable nationwide to individuals as well as businesses, employers and employees as follow:

i. The introduction of a night time curfew from a specific time till dawn;

ii. The usage of non-medical face masks or coverings by everyone. This means that all movements during this time will be prohibited, with the exception of those required for essential services;

iii. the provision of hand-washing facilities and sanitizers in public places;

iv. restrictions on interstate travel, with the exception of those required for the transportation of agricultural produce and other essential goods;

v. extensive temperature checks upon entry into the business premises and other public places; and

vi. no large gatherings of more than 20 people outside the workplace.

The COVID-19 pandemic is a problem for many parties, including property managers, current and potential renters, landlords, maintenance staff, and other affiliates, according to the National Association of Residential Property Managers (NARPM, 2020). They offered the following precautions, which were in line with the Centres for Disease Control precautions, since they thought it prudent for its members and affiliates to be ready for situations using COVID-19:

Inspections

i. Using technology provided by NARPM Affiliates that can help at this period, doing electronic inspections and virtual tours, as well as making follow-up phone calls to restrict public contact and keep filling vacancies.

ii. Prior to, during, and after an inspection, implement cleaning and disinfection procedures in accordance with the CDC's recommendations after assessing the risk based on your specific area.

iii. Limiting your interactions with others and requesting COVID19 documentation before dispatching any workers for maintenance issues, etc.

Payments for rent and security deposits

i. only accept rent payments made online.

ii. Establishing payment schedules and putting all agreements in writing.

iii. Making use of technology to receive money wired into a particular account or take security deposits.

iv. Continuing to enforce contracts in accordance with the law.

v. Remaining familiar about COVID-19's most recent eviction legislation (laws vary – consult your legal professional).

vi. Keeping abreast of new resources that may be available to help landlords who are experiencing financial difficulty as a result of COVID-19.

Based on literature review, a summary of the covid-19 measures is presented in table 1. These measures were selected based on the opinion of (NCDC, 2020; NARPM, 2020; RICS, 2020). In summary, there is lack of empirical evidence about the assessment of property management practice during and after covid-19 pandemic in Nigeria. The study is therefore significant because the spread of this virus and the possible impact on real estate practices are key factors of concern to the continuous existence of property management practices. Lastly, the result of the study is expected to be a guiding tool to property managers towards a property management best practice.

Table 8": Covid-19 measures based on literature review

S/N	***Control Measures on COVID-19 Pandemic***	***NCDC (2020) Guideline for Employers & Businesses in Nigeria***	***National Association of Residential Property Managers (NARPM)***	***(Property management and covid-19 quick guide)*** *Real Estate Board of New York*
1.	***TENANT PLACEMENT***			
a.	***Inspection***			
	Performing electronic showings and virtual tours using technology offered by NARPM Affiliates that can assist you during this time, along with follow-up phone calls to limit public contact and to keep filling vacancies			
	Physical inspection with prospective tenant without touching any fixtures and fittings in the building and also observing every covid-19 precaution such as wearing of face mask, social distancing and sanitizing of hands.			
b.	***Rent Payments***			
	Payment via cheque.			
	Payment of rent into firm's account and bringing of bank teller or slip for acknowledgement.			
	Payment via bank transfer into firms' account.			
	Payment with cash			
	Payment via online bank transfer.			
	Payment via bank draft			
2.	***MAINTENANCE AND REPAIRS***			
	Essential Repairs (plumbing, heating, electrical, safety, habitability and sanitation).			
	Non-essential repairs (routine repairs such as painting, minor plumbing repairs, minor plastering works, cracked tiles, etc.)			
	Increasing maintenance and cleaning of common areas in buildings	/		/
	Requesting (but NOT requiring) that tenants let property managers know if anyone in their household has contracted the virus so that outside vendors and staff don't enter the property to perform maintenance work or mid-lease and annual inspections. Note: remember privacy, respecting privacy and only sharing general information, not specifics.			
	Limiting your contact with others and requiring documentation regarding COVID19 before sending any staff for maintenance issues, etc.			
	Instituting strict protective procedures for maintenance workers with requests involving threatening health and safety conditions and welfare of the tenant/home conditions.			
3.	***PROPERTY ADMINISTRATION***			
a.	***Routine Inspection***			
	Virtual routine inspection with tenant using video enabled devices and applications such as WhatsApp, Skype, Zoom and many others.	/	/	

	Physical inspection to residential properties without touching any fixtures and fittings in the building and also observing every covid-19 precaution such as wearing of face mask, social distancing and sanitizing of hands.	/		
	Assessing risk based on your specific location for in-person showings and instituting cleaning and disinfecting protocols in accordance with the CDC recommendations before, during and after an in-person showing		/	
	Putting off all routine inspections for future dates in single family homes.			/
b.	***Service Charge (RICS)***			
	Imposing an additional fee to service charge to cover costs to perform an additional cleaning of areas used for move.			
	Reluctant of tenants to continue contributing towards the landlords' cost of providing services at a time when they themselves have been forced to suspend operations in accordance with government restrictions			
	Tenants continue to pay their service charges as set out in their lease but landlords and occupiers may wish to negotiate appropriate temporary service charge arrangements, and these negotiations should take place in a constructive and collaborative manner.			
c.	***Move-outs***			
	Mandating cleaning procedures at a minimum follow CDC recommendation.			
	Mandating a "vacancy period" before anyone enters a unit/home.			
	Performing move-out inspections separate from tenants after an appropriate "vacancy period".			
4.	***General measures***			
	Washing of hands with soap and running tap water for at least 20 seconds after being in a public place or frequently clean hands by using alcohol-based hand rub;			
	If soap and water are not immediately available, use an alcohol-base hand sanitizer that contains at least 60% - 70% alcohol			
	Use 10 ml of Dettol plus 1 ml of sodium hypochlorite (bleach) in 100 ml of clean water to decontaminate surfaces; Avoid touching, nose, eyes and mouth with unwashed hands;			
	Put distance (2-meter gap) between oneself and others as community			
	Mandatory provision of handwashing facilities/sanitizers.			
	Restrictions on interstate travel except for essential services or transportation of agricultural produce and other essential goods			
	Extensive temperature checks on entry into the business premises and other public places.	/		

Methodology

The Estate Surveying and Valuation firms in Lagos are the target population for this study. This is because Lagos is the most affected States in Nigeria (epicentre of Covid-19), and has the highest property demand and management practices. There are 352 registered firms of Estate Surveying and Valuation in the study area according to the 2017 directory of Nigeria Institution of Estate Surveyors and Valuers (NIESV). Systematic random sampling technique was adopted in selecting every second member on the NIESV directory as the sample size which gives a total of 176 Estate Surveying and Valuation firms that responded to the copies of questionnaire prepared on a five-point Likert scale format of "Always (5)" to "Never (1)". Weighted Mean Score (WMS) and Wilcoxon Signed-Rank Test were employed as a tool for data analysis. WMS was used to assess the weighted response of the respondents. While Wilcoxon Signed-Rank Test were used for comparing two sets of scores (i.e., management practice during and after covid-19 pandemic) that comes from the same respondents in order to determine any change in response from one time point to another.

Results and Discussion

According to Literature, the general property management practices include: tenant placement, maintenance and repairs, and property administration. A survey was conducted from a sample of practising estate surveyors and valuers in Lagos, data on this was collected on five Likert scale format of Always (5), Most of the time (4), Sometimes (3), Rarely (2), and Never (1) on how they carry out their duties during and after covid-19 pandemic. The Weighted Mean Score (WMS) of their responses is presented in Table 2.

Inspection

From Table 2, the result of the inspection showed that physical inspection with prospective tenant without touching any fixtures and fittings in the building and also observing every covid-19 precaution such as wearing of face mask, social distancing and sanitizing of hands was ranked 1st with a mean score of 3.81. This is followed by Virtual inspection with client using video enabled devices and applications such as whats app, Skype, Zoom e.t.c. with a mean of 2.53. However, the same was ranked 1st and 2nd respectively after covid-19 pandemic with a mean of 4.35 and 2.88. This is an indication that property managers are yet to fully implement the use of virtual inspection in property management practices. However, this result is in line with Oladokun (2010) which was of the opinion that for us to have a sustainable property management practice, there must be a thirst for change and conformity with recent management trend.

Mode of payment

The result of the mode of payment from table 2 showed that during covid-19 pandemic, Payment via online bank transfer was ranked first with a mean score of 4.66. This could be attributed to the fact that people prefer online banking in settlement of payment during covid-19 pandemic in order to avoid coming in contact with people in the banking hall. The same was ranked first after covid-19 pandemic with a mean score of 4.52. This implies that even after covid-19 pandemic people still prefer payment through online bank transfer. This is followed by payment via cheque with a mean score of 4.21. Next is payment into firms account using bank teller with a mean of 3.68. This was also ranked third after the pandemic with a mean of 2.75. The implication of this result is that the covid-19 measure has caused people to be more acquainted with other medium of payment rather than going to bank to queue. Next to this is payment via bank transfer into firms account, payment via bank draft, and payment with cash with a mean score of 3.68, 3.65, 1.58 and 1.33 respectively. It can be deduced that payment with cash has the lowest mean and this is because majority of firms never accept cash from tenants to avoid spending client's money.

Maintenance and Repair

Under the maintenance and repair category, essential repairs work such as plumbing, heating, electrical, safety, habitability and sanitation was majorly attended to by the property managers during covid-19 pandemic lockdown and this was ranked first with a mean score of 4.60. This practice was also followed by iinstituting strict protective procedures for maintenance workers having a mean score of 4.29. Next to this is increasing maintenance and cleaning of common areas in buildings which has a mean of 3.85. Requesting that tenants let property managers know if anyone in their household has contracted the virus so that outside vendors and staff don't enter the property to perform maintenance work or mid-lease and annual inspections, and non-essential repairs (routine repairs such as painting, minor plumbing repairs, minor plastering works, cracked tiles, etc.) was ranked fourth and fifth and with a mean score of 3.81 and 3.32 respectively. It is interesting to know that after the pandemic, more priority was given to increasing maintenance and cleaning of common areas in buildings than essential repair work which has a mean of 4.80 and 4.66 respectively. Next to this is instituting strict protective procedures for maintenance workers which has a mean score of 4.40. The implication of this result is that property managers are focusing more on preventive measures than its cure.

Routine Inspection

Physical inspection to residential properties without touching any fixtures and fittings in the building and also observing every covid-19 precaution such as wearing of face mask, social distancing and sanitizing of hands was ranked first during and after covid-19 pandemic having a mean of 4.30 and 4.22. Next is virtual routine inspection with tenant using video enabled devices and applications such as WhatsApp, Skype, Zoom and many others during and after covid-19 with a mean 3.23 and 2.59. The implication of this result is that the application of technology is till at its infancy in property management practice. Putting off all routine inspections for future dates in single family homes was ranked last during and after covid-19 pandemic with a mean of 2.37 and 1.35. This implies that even after covid-19 pandemic all routine inspection is still under suspension. ***Service Charge (RICS)***

Reluctant of tenants to continue contributing towards the landlords' cost of providing services at a time when they themselves have been forced to suspend operations in accordance with government restrictions was ranked first with a mean of 3.03. This is followed by imposing an additional fee to service charge to cover costs to perform an additional cleaning of areas used for movement which has a mean of 3.01. Next to it is tenants continue to pay their service charges as set out in their lease but landlords and occupiers may wish to negotiate appropriate temporary service charge arrangements, and these negotiations should take place in a constructive and collaborative manner, and this has a mean of 2.92. After covid-19, it is interesting to see that imposing an additional fee to service charge to cover costs to perform an additional cleaning of areas used for movement was ranked the least with a mean of 1.86. This is followed by reluctant of tenants to continue contributing towards the landlords' cost of providing services at a time when they themselves have been forced to suspend operations in accordance with government restrictions with a mean of 2.03. This implies that property managers no longer need to impose service charge on tenant before they pay. This assertion was confirmed true as the variable "tenants continue to pay their service charges as set out in their lease but landlords and occupiers may wish to negotiate appropriate temporary service charge arrangements, and these negotiations should take place in a constructive and collaborative manner" was ranked first with a mean of 3.65.

Move-outs

Table 1 also revealed that during covid-19 pandemic, mandating cleaning procedures at a minimum follow CDC recommendation is ranked first with a mean score of 4.05 followed by mandating a "vacancy period" before anyone enters a unit/home having a mean score of 1.97 and lastly is performing move-out inspections separate from tenants after an appropriate "vacancy period" with a mean score of 1.82. After covid-19 pandemic the result showed a slight change in the procedure for moving out. Mandating cleaning procedures at a minimum follow CDC recommendation retained the first position with a mean score of 2.75, followed by performing move-out inspections separate from tenants after an appropriate "vacancy period" which has a mean score of 1.71 and next to it is mandating a "vacancy period" before anyone enters a unit/home with a mean of 1.47.

In order to further analyse if there is significant difference in respondents report on their management practice during and after covid-19 pandemic, Wilcoxon Signed-Rank Test was used and the result is presented in Table 3. According to SPSS survival manual version 12, two things are important in the interpretation of Wilcoxon Signed-Rank test output and these are the Z value and the associated significance levels, presented as Asymp. Sig. (2-tailed) (Pallant, 2005).

If the significance level is equal to or less than 0.05 (e.g., .04, .01, .001) then one can conclude that the difference between the two scores is statistically significant. Table 3 showed that out of all the 22 variables considered only one is not statistically significant at an agreed critical p-value of 0.05 (significant level). Therefore, it can be said that the survey conducted on the two sets of property management practice (during and after covid-19 pandemic) are statistically significantly different. Therefore, this study concluded that the property management practice during and after covid-19 are significantly different for all type of management practice except for the mode of payment via bank draft which is not significantly affected during and after covid-19 pandemic.

Table 2: Weighted mean response of respondents on property management practices

S/N	*PROPERTY MANAGEMENT PRACTICES*	*DURING COVID-19*			*AFTER COVID-19*		
		ST. D	*Mean*	*Rank*	*ST. D*	*Mean*	*Rank*
1.	***TENANT PLACEMENT***						
a.	***Inspection***						
	Physical inspection with prospective tenant without touching any fixtures and fittings in the building and also observing every covid-19 precaution such as wearing of face mask, social distancing and sanitizing of hands.	0.396	3.81	1st	0.478	4.35	1st
	Virtual inspection with client using video enabled devices and applications such as WhatsApp, Skype, Zoom and many others.	1.208	2.53	2nd	0.907	2.88	2nd
b.	***Rent Payments***						
	Payment via online bank transfer.	0.922	4.66	1st	0.638	4.52	1st
	Payment via cheque.	0.795	4.21	2nd	0.704	2.30	4th
	Payment of rent into firm's account and bringing of bank teller or slip for acknowledgement.	1.188	3.68	3rd	0.706	2.75	3rd
	Payment via bank transfer into firms' account.	1.023	3.65	4th	1.031	4.05	2nd
	Payment via bank draft	0.889	1.58	5th	0.663	1.58	6th
	Payment with cash	0.782	1.33	6th	1.292	1.75	5th
2.	***MAINTENANCE AND REPAIRS*** *(Property management and covid-19 quick guide)*						
	Essential Repairs (plumbing, heating, electrical, safety, habitability and sanitation).	0.491	4.60	1st	0.476	4.66	2nd
	Instituting strict protective procedures for maintenance workers.	0.919	4.29	2nd	0.786	4.40	3rd
	Increasing maintenance and cleaning of common areas in buildings	0.952	3.85	3rd	0.401	4.80	1st
	Requesting (but NOT requiring) that tenants let property managers know if anyone in their household has contracted the virus so that outside vendors and staff don't enter the property to perform maintenance work or mid-lease and annual inspections.	1.532	3.81	4th	1.816	2.74	5th
	Non-essential repairs (routine repairs such as painting, minor plumbing repairs, minor plastering works, cracked tiles, etc.)	0.890	3.32	5th	0.536	4.19	4th
3.	***PROPERTY ADMINISTRATION***						

a.	***Routine Inspection***						
	Physical inspection to residential properties without touching any fixtures and fittings in the building and also observing every covid-19 precaution such as wearing of face mask, social distancing and sanitizing of hands.	0.461	4.30	1st	0.415	4.22	1st
	Virtual routine inspection with tenant using video enabled devices and applications such as WhatsApp, Skype, Zoom and many others.	1.423	3.23	2nd	0.700	2.59	2nd
	Putting off all routine inspections for future dates in single family homes.	1.834	2.37	3rd	0.478	1.35	3rd
b.	***Service Charge (RICS)***						
	Reluctant of tenants to continue contributing towards the landlords' cost of providing services at a time when they themselves have been forced to suspend operations in accordance with government restrictions	0.973	3.03	1st	1.227	2.03	2nd
	Imposing an additional fee to service charge to cover costs to perform an additional cleaning of areas used for move.	1.579	3.01	2nd	1.001	1.86	3rd
	Tenants continue to pay their service charges as set out in their lease but landlords and occupiers may wish to negotiate appropriate temporary service charge arrangements, and these negotiations should take place in a constructive and collaborative manner.	1.673	2.92	3rd	1.097	3.65	1st
c.	***Move-outs***						
	Mandating cleaning procedures at a minimum follow CDC recommendation.	1.205	4.05	1st	1.181	2.75	1st
	Mandating a "vacancy period" before anyone enters a unit/home.	1.613	1.97	2nd	0.724	1.47	3rd
	Performing move-out inspections separate from tenants after an appropriate "vacancy period".	1.176	1.82	3rd	1.105	1.71	2nd

Conclusion and Recommendation

In conclusion, this study has been able to assessed the property management practices during and after Covid-19 pandemic. From the weighted mean responses of property managers, the results revealed that there are changes in the management practices during and after covid-19 pandemic. A further analysis using Wilcoxon Signed-Rank Test also showed that the property management practice during and after covid-19 are significantly different for all type of management practice except for the mode of payment via bank draft which is not significantly affected during and after covid-19 pandemic.

The contribution of this study to the body of knowledge is that it will help property managers in carrying out an efficient property management practices at such a time of Covid-19 pandemic.

Table 3: Wilcoxon Signed-Rank Test- Test Statistics

S/N	*PROPERTY MANAGEMENT PRACTICES*	*Z*	*Asymp. Sig. (2-tailed)*
1.	***TENANT PLACEMENT***		
a.	***Inspection***		
	Virtual inspection with client using video enabled devices and applications such as whats app, Skype, Zoom and many others.	-5.140^b	.000
	Physical inspection with prospective tenant without touching any fixtures and fittings in the building and also observing every covid-19 precaution such as wearing of face mask, social distancing and sanitizing of hands.	-10.183^b	.000
b.	***Rent Payments***		
	Payment via cheque.	-11.504^b	.000
	Payment of rent into firm's account and bringing of bank teller or slip for acknowledgement.	-9.079^b	.000
	Payment via bank transfer into firms' account.	-7.508^b	.000
	Payment with cash	-5.500^b	.000
	Payment via online bank transfer.	-2.252^b	.024
	Payment via bank draft	$.000^b$	1.000
2.	***MAINTENANCE AND REPAIRS*** *(Property management and covid-19 quick guide)*		
	Essential Repairs (plumbing, heating, electrical, safety, habitability and sanitation).	-3.000^b	.003
	Non-essential repairs (routine repairs such as painting, minor plumbing repairs, minor plastering works, cracked tiles, etc.)	-10.956^b	.000
	Increasing maintenance and cleaning of common areas in buildings	-8.744^b	.000
	Requesting (but NOT requiring) that tenants let property managers know if anyone in their household has contracted the virus so that outside vendors and staff don't enter the property to perform maintenance work or mid-lease and annual inspections. Note: remember privacy, respecting privacy and only sharing general information, not specifics.	-8.463^b	.000
	Instituting strict protective procedures for maintenance workers.	-3.545^b	.000
3.	***PROPERTY ADMINISTRATION***		
a.	***Routine Inspection***		
	Virtual routine inspection with tenant using video enabled devices and applications such as WhatsApp, Skype, Zoom and many others.	-6.919^b	.000
	Physical inspection to residential properties without touching any fixtures and fittings in the building and also observing every covid-19 precaution such as wearing of face mask, social distancing and sanitizing of hands.	-3.606^b	.000
	Putting off all routine inspections for future dates in single family homes.	-7.136^b	.000
b.	***Service Charge (RICS)***		
	Imposing an additional fee to service charge to cover costs to perform an additional cleaning of areas	-9.512^b	.000

	used for move.		
	Reluctant of tenants to continue contributing towards the landlords' cost of providing services at a time when they themselves have been forced to suspend operations in accordance with government restrictions	-9.328[b]	.000
	Tenants continue to pay their service charges as set out in their lease but landlords and occupiers may wish to negotiate appropriate temporary service charge arrangements, and these negotiations should take place in a constructive and collaborative manner.	-8.110[b]	.000
c.	***Move-outs***		
	Mandating cleaning procedures at a minimum follow CDC recommendation.	-9.851[b]	.000
	Mandating a "vacancy period" before anyone enters a unit/home.	-6.100[b]	.000
	Performing move-out inspections separate from tenants after an appropriate "vacancy period".	-2.795[b]	.005

It will also be beneficial to the Nigerian Institution of Estate Surveyors and Valuers in the modulation and formulation of policies for a sustainable property management practice. However, this study recommends that strict compliance should be given to all covid-19 measures relating to property management practices as coronavirus is real and still very much out there. Also, the application of ICT technology should be fully adopted in property management practices to allow for a sustainable and efficient property management practices.

References

Cheng, Y.C. (1998). The Knowledge Base for Re-engineering Schools: Multiple Functions and Internal Effectiveness. *International Journal of Educational Management* 12(5), 24-33

Macey, J.P. and Baker, C.V. (1978), *Housing Management*, Estate Gazette, London.

NARPM (2020) The National Association of Residential Property Managers (NARPM) Statement and Position on COVID-19 (Coronavirus). www.narpm.org

NCDC (2020) COVID-19 Outbreak in Nigeria Situation Report.

NCDC (2020) Guideline for Employers and Businesses in Nigeria.

Nevada State Real Estate Division (2008). Property Management. Available at http://www.red.state.nv.us/publications/bulletins/IB12-Property%20Management.pdf. (Accessed on March 20, 2021)

Nigeria Centre for Disease Control. COVID-19 Nigeria. Abuja, Nigeria. (2020). Available online at: https://covid19.ncdc.gov.ng (accessed 7 June 2020).

Nigerian real estate and covid in 19 slide (2020), Real estate intel research@estateintel.com www.estateintel.com

Ogunba, A. O. and Iroham E. (2005), Globalisation and Professional Institutions: Challenges to the Nigerian Real Estate Profession. In Okewole, I.A., Daramola, S.A., Ajayi, C.A., Ogunba, O.A., and Odusami, K.T., ed. *The Built Environment: Innovation Policy and Sustainable Development, Ota, Nigeria*, 186-195.

Oladokun T.T. (2010) Sustainable Property Management Practice In Nigeria. Proceedings of International Research Conference on Sustainability in Built Environment, Columbia, Sri Lanka, 18th and 19th June, 2010, pp 157-165.

Oyedeji J.O. (2020). The Impact of COVID-19 on Real Estate Transaction in Lagos, Nigeria. *INTREST – International Journal of Real Estate Studies*, 107-112

Pallant, Julie (2005)-. SPSS survival manual: a step-by-step guide to data analysis using SPSS, 3rd edition. Australia: Allen & Unwin

Scarret, D. (1995), Property Asset Management, E & FN SPON, London

Thoncroft M. (1976), *Principles of Estate Management*, London: The Estate Gazette Ltd, London

Tomori, A. (2005), Tit Bits on Successful Property Managemnt. *The Nigerian Institution of Estate Surveyor and Valuer Journal*. 28 (2), 30-32.

World Health Organization. COVID-19 pandemic expands reach in Africa. WHO Regional Office for Africa, Brazzaville, Republic du Congo (2020): Available online at: https://www.afro.who.int/news/covid-19-pandemic-expands-reach-africa (accessed 2 June 2020).

Zhanda K. (2020). Beyond Recovery? Downturns, Implications and Prospects of COVID-19 Pandemic to Real Estate Development in Zimbabwe. *INTREST – International Journal of Real Estate Studies* 14: S1 (2020), 31-40.

An Assessment of Valuation Accuracy in the Residential Property Markets in Minna and Abuja

Dangana, U. S. & **Udoekanem, N. B.**
Department of Estate Management and Valuation, Federal University of Technology, Minna, Nigeria
umarthe2nd@gmail.com; namnsoudoekanem@futminna.edu.ng
corresponding author: umarthe2nd@gmail.com;

Abstract
The crash of the property market in the 1980s kick-started the pursuit for accurate valuation to retain public confidence in the valuation profession and to forestall dire legal consequences. This study assessed valuation accuracy in the residential property markets in Minna and Abuja with a view to ascertaining the level of valuation accuracy in these markets, identifying the factors that significantly cause valuation inaccuracy and measures that could mitigate such causes. Data for the study were collected via structured questionnaire administered to 179 estate surveying and valuation firms in the study area using census sampling technique. Analytical techniques such as median percentage error, mean, standard deviation and bivariate regression analysis were employed in the analysis of data collected for the study. The study found that the ability of valuation to predict actual price is greater in the residential property market in Abuja (93.7%) than in Minna (87.6%), with wrong valuation methodology being the most causative factor of valuation inaccuracy. It is recommended that a national databank for valuations in the country is established as well as strict enforcement of valuation standards and code of ethical conduct by the regulatory authorities in the valuation profession.
***Keywords**: Valuation Accuracy, Property Market, Residential Properties, Minna, Abuja*

Introduction

According to The International Valuation Standard Council (2022), valuation is the act or process of determining an opinion or conclusion of value of an asset on a stated basis of value at a specified date in compliance with international valuation standards. It is an opinion of the value of an asset or liability on a stated basis, at a specified date (RICS, 2022). It can also be defined as all the processes involved in forming an opinion of the value of real property, usually the market value or the science of estimating the worth of real property, taking into consideration the purpose of valuation and plethora of factors that affect value (Kilpatrick 2007; Olayonwa 2006).

The pursuit for "accurate" valuations was triggered by a handful of factors including the crash of the property and financial markets in the 1980s, the work of Hager and Lord (1985), as well as the 1990 – 1994 recession that led to financial institutions blaming valuers for their inability to sell mortgaged properties at valuers' opinions of value. The aforementioned brought unnecessary attention from tabloids, the academia and the general public which negatively affected the public's confidence in both the valuation process and the valuation profession (Babawale, 2021). As a result, researchers across Europe (UK especially), North America and Australia have in the past three decades launched an enquiry into the degree to which valuations provide acceptable predictions of realised price and valuations. These studies include Parker (1999), McAllister (1995), Cannon and Cole (2011) Baum, Crosby, Gallimore, McAllister and Gray (2000) and Reinert (2020) and their findings exposed valuation accuracy issues with margin of error exceeding the permissible limit.

Similarly, in Nigeria, studies conducted have shown valuations having an alarming margin of error of up to ±65%, ±201%, ±71%, ±113%, ±119%, ±25% and ±88%; which are not in alliance with the established and acceptable margin (Ayedun, Ogunba & Oloyede 2010; Effiong & Mendie, 2019). Factors noted as instrumental for the stray of values from the tolerable margin of error are valuation methodology employed, client pressure, inadequate academic training amongst others (Oduyemi, 2016; Ajibola, 2010; Aliyu, Sani, Usman & Muhammad, 2018) and if left unchecked as Effiong and Mendie (2019) argued, will lead to upsurge in lawsuits. The objectives are to:

ascertain the level of valuation accuracy in the residential property markets in Minna and Abuja;

identify the factors that significantly influence valuation accuracy in residential property markets in the study areas; and identify measures that could mitigate valuation inaccuracy in the residential property markets in the study areas.

Literature Review

Bretten and Wyatt (2001) examined the causes of valuation variance in commercial property valuations. The study found that a margin of error of ±10% most fitting. Cannon et al. (2011) evaluated the accuracy of commercial real estate appraisals conducted in a 26 years' time frame (1984-2010). The study revealed that valuations done were more than 10% above, or below, subsequent sales prices. Ayedun et al. (2018) examined the causes of valuation inaccuracy in Lagos. Using mean ranking, the study revealed that the causes of inaccuracy include: the dearth of data, ineffective regulation, and lack of compliance with valuation standards amongst others. Oduyemi et al. (2016) investigated causes of inaccuracy in commercial office buildings. Using mean ranking, factor and regression analyses. The study revealed that skill, type of property, experience and judgement of the valuer, integrity of the valuer and the absence of valuation standard manual were the four causes with statistically unique contribution to valuation accuracy.

Previous studies on valuation accuracy both foreign and local have traced the lack of valuation accuracy to a plethora of reasons. However, the focus has been on commercial properties with only a handful investigating valuation accuracy in residential properties. A population gap is also highlighted as seen in the dearth of valuation accuracy studies focusing on the property markets in Northern Nigeria as most studies were carried out in South-Western Nigeria. Considering these shortcomings, an assessment of valuation accuracy in the residential property markets in Abuja and Minna has become necessary.

Research Methodology

Research Design and Sampling Technique

The research design adopted for this study is causal design. The population for the study comprises all registered estate surveying and valuation firms in Minna and Abuja. Data on residential properties sold recently in the study areas and the amount they were initially valued for were sourced from these firms. The breakdown of the population is shown in the Table 1:

Table 1: Distribution of registered estate surveying and valuation firms in the study areas

Location	***No. of Registered ESV Firms***
Minna	*11*
Abuja	*168*
Total	***179***

Source*: NIESV Online Directory (2022)*

All registered estate surveying and valuation firms in the study areas were selected for the study through census sampling technique. This sampling technique was adopted for the study because it entails the selection of all the members of the population under study.

Method of Data Collection

Data were collected through field survey using structured questionnaire administered to registered firms of Estate Surveyors and Valuers in the study areas. The questionnaire was designed with closed – ended questions, organised in three sections. The first section of the questionnaire contained questions intended to elicit information on the profile of the respondents. The second section of the questionnaire contained fifteen opinion statements on the causes of inaccuracy in residential property valuations in the study areas and measures proposed to mitigate them. These causes were distilled from the literature of earlier empirical studies on the issue specifically, Babawale (2006), Babawale and Ajayi (2011), Babawale and Omirin (2011), Ayedun et al (2018) and Aliyu et al (2018). These opinion statements were measured using a 5-point Likert-type scale (strongly agree = 5; strongly disagree = 1). The last section of the questionnaire was designed to produce data on residential properties recently sold by the *respondent firms of estate surveyors and valuers in the study areas and their corresponding valuer's valuation opinion. The administration of the questionnaire is presented in Table 2.*

Table 2: Questionnaire administration in the study areas

Location	Questionnaire Administered	Questionnaire Returned	Response Rate (%)
Abuja	168	110	65
Minna	11	8	72

Data Analysis Techniques

Data obtained for the study were analysed using descriptive and inferential statistical techniques. These techniques include percentage error, median percentage error, weighted mean, standard deviation, bivariate regression analysis and rank-order correlation analysis. For an individual property, the model recommended by the Australian Property Institute (API, 2012) was utilised to determine the percentage error. Based on the model, if actual price is greater than valuation, the percentage error is:

$$Percentage\ Error = 100\frac{(Actual\ Price - Valuation)}{Actual\ Price} \quad (1)$$

The average percentage error for a sub-residential property market under study was measured using the median percentage error (MPE) model. The model is:

$$MPE = L + \left[\frac{\frac{N}{2} - fl}{fm}\right]C \quad (2)$$

$Where\ MPE = Median\ Percentage\ Error$

$L = Lower\ class\ boundary\ of\ the\ MPE\ class$

$N = Total\ number\ of\ valuations$

$fl = Sum\ of\ frequencies\ of\ all\ classes\ below\ the\ MPE\ class$

$fm = Frequency\ of\ the\ MPE\ class$

$C = Class\ Interval$

In determining the factors that significantly influence valuation accuracy in the study areas, the weighted mean and standard deviation of the responses were used to rank the factors while bivariate regression was employed to assess the extent to which valuation could predict actual price in the residential property markets under study. The regression equation is:

$$y = a + \beta x + e \quad (3)$$

Where:

$y \quad = actual\ price$

$a \quad = intercept$

$\beta \quad = regression\ coefficient$

$x \quad = valuation$

$e \quad = error\ term$

Results and Discussion

The profile of the respondent estate surveyors and valuers is presented in Table 3. 90% of the respondents in Minna are males and HND is the dominant academic qualification with 50% of occurrence. Majority of the respondents in Minna (60%) are registered estate surveyors and valuers with 70% of them carrying out at least 3 valuations in a month. In addition, 30% of them have attended 3-5 MCPD programmes in the last 24 months.

Thus, it can be inferred that the respondents are knowledgeable and active practitioners of the estate surveying and valuation profession in Minna. In Abuja, 86% of the respondents are male while HND and BSc are their main academic qualifications, representing 44% and 41% of occurrence, respectively. In addition, 61% of the respondents are professional members of the NIESV and 50% carryout at least 3 to 5 valuations in a month. Furthermore, about 42% of the respondents in Abuja have attended at least1 to 2 MCPD seminars in the last 24 months. In conclusion, it can be deduced that respondents in Abuja are educated, experienced and knowledgeable in property valuation to *participate in the study.*

Table 3: Profile of the Respondents under study

	Minna	***Abuja***
Variable		
Academic Qualifications		
OND		*3 (2%)*
HND	*5 (50.0%)*	*48 (44%)*
BSC	*3 (30.0%)*	*45 (41%)*
MSC	*2 (20.0%)*	*13 (12%)*
PHD		*1 (1%)*
Professional Qualifications		
ANIVS	*6 (60.0%)*	*67 (61%)*
FNIVS	*4 (40.0%)*	*8 (7%)*
Others		*35 (32%)*
Valuations per month		
0-3	*7 (70.0%)*	*27 (24%)*
4-5	*1 (10.0%)*	*55 (50%)*
6-10	*2 (20.0%)*	*19 (17%)*
10-20		*6 (6%)*
20-30		*1 (1%)*
30 and above		*2 (2%)*
Attend MCPD, seminars and lectures?		
Yes	*10 (100%)*	*110 (100%)*
No	*0 (0%)*	*0 (0%)*
MCPD/seminars attended over the last 24 months		
1-2	*4 (40.0%)*	*46 (42%)*
3-5	*2 (20.0%)*	*50 (45%)*
6-10	*4 (40.0%)*	*10 (9%)*
10 and above		*4 (4%)*

Table 4 itemizes the 15 residential property transactions conducted in Minna recently. The data is divided into 9 sub-markets showing the description and location of the property, sale price and valuer's valuation opinion, as well as the margin of error and median percentage error for each sub-market. Using a margin of error of ±15% which is the acceptable level of variation (API, 2012), the Table indicates valuation inaccuracy of extreme proportions (42% - 100%). Summarily, only 27% of the 15 property transactions were within the acceptable margin of error making the remaining 73% inaccurate. An observation of the median percentage error shows that valuations were within the acceptable margins in Mandela Road and Sauka Kahuta sub-markets.

Table 4: Level of valuation accuracy in the residential property market in Minna

S/N	***Description of Property***	***Location***	***Actual Sale Price (₦)'m***	***Valuers Valuation Opinion (₦)'m***	***Margin of Error (%)***	***Median Percentage Error (%)***
1	*5 bedroom detached bungalow*	*Mandela Road*	*7.8*	*8*	*3*	*3*
2	*2 bedroom detached* *3 bedroom detached*	*Morris* *Morris*	*3.5* *3.5*	*3.8* *7*	*9* *100*	*55*
3	*5 bedroom detached* *3 bedroom flat* *3 bedroom flat*	*Bosso* *Bosso* *Bosso*	*18* *6.5* *12*	*29* *9* *9*	*61* *38* *25*	*38*
5	*Tenement* *4 bedroom and BQ*	*Maitumbi* *Maitumbi*	*6* *18*	*8* *22*	*33* *22*	*28*

6	5 bedroom flat	London street	23	28	21	21
7	2 bedroom detached	Tunga	7	8.5	21	21
	2 bedroom detached	Tunga	5.5	6	9	
	2 bedroom detached	Tunga	6	8.5	42	
8	2 bedroom detached	Barkin Sale	3.5	5	43	43
9	3 bedroom detached	Sauka Kahuta	18	17	6	9
	2 bedroom detached	Sauka Kahuta	4.5	5	11	

Residential property transactions conducted in Abuja are presented in Table 5. The data is isolated into 26 sub-markets and includes the description and location of the property, sale price and valuer's valuation opinion, as well as the margin of error and median percentage error for each sub-market. Using a margin of error of ±15% which is the acceptable level of variation (API, 2012), the Table shows varying proportions of valuation inaccuracy (33% - 50%). Besides, 52% of the 117 transactions exceeded the acceptable margin of error. It was also observed that valuations were inaccurate in certain sub-markets compared to others. These include Kubwa, Galadimawa, Lifecamp, Katampe, Guzape, Kaura Karu, Dakwo, Apo, Jabi and Lokogoma.

Table 5: Level of valuation accuracy in the residential property market in Abuja

S/N	Description of Property	Location	Actual Sale Price (₦)'m	Valuer's Valuation Opinion (₦)'m	Margin of Error (%)	Median Percentage Error (%)
1	2 bedroom	Kubwa	7.5	10	33	16
	3 bedroom duplex	Kubwa	40	35	12	
	5 bedroom bungalow on 2000sqm plot	Kubwa	720	650	9	
	5 bedroom duplex	Kubwa	217	200	7	
	6 bedroom duplex	Kubwa	60	45	25	
	3 bedroom flat	Kubwa	120	80	33	
	6 unit 2 bedroom	Kubwa	150	120	20	
	5 bedroom detached	Kubwa	15	12	20	
	2 bedroom flat	Kubwa	87	90	3	
	10 bedroom duplex	Kubwa	38	39	2	
2	3 bedroom	Guzape	130	150	15	12
	5 bedroom detached	Guzape	90	110	22	
	4 bedroom duplex	Guzape	92	85	7	
	5 bedroom detached	Guzape	210	250	19	
	5 bedroom apartment	Guzape	165	140	15	
	5 bedroom duplex	Guzape	100	110	10	
	2 bedroom apartment	Guzape	37	30	18	
	4 bedroom duplex	Guzape	265	280	5	
	4 bedroom duplex	Guzape	185	150	18	
	5 bedroom mansion	Guzape	300	320	6	
	5 bedroom duplex	Guzape	95	100	5	
	5 bedroom duplex	Guzape	286	300	4	
	5 bedroom semi detached					
	4 bedroom duplex	Guzape	140	160	14	
		Guzape	124	130	4	
3	4 bedroom semi-detached	Lifecamp	112	110	1	12
	3 bedroom flat					
	3 bedroom apartment	Lifecamp	24	18	25	
	4 bedroom duplex	Lifecamp	27	30	11	

	5 bedroom duplex	*Lifecamp*	*195*	*170*	*12*	
	5 bedroom	*Lifecamp*	*250*	*200*	*20*	
	3 bedroom bungalow	*Lifecamp*	*100*	*80*	*20*	
	5 bedroom duplex	*Lifecamp*	*47*	*45*	*4*	
		Lifecamp	*192*	*200*	*4*	
4	*4 bedroom semi detached*	*Gudu*	*43*	*45*	*4*	*4*
5	*2 bedroom flat*	*Karsana*	*5*	*4.5*	*10*	*10*
	5 bedroom duplex	*Karsana*	*20*	*18.3*	*8*	
	5 bedroom duplex	*Karsana*	*200*	*200*	*0*	
	5 bedroom duplex	*Karsana*	*112*	*130*	*16*	
	5 bedroom detached	*Karsana*	*127*	*145*	*14*	
6	*7 bedroom duplex*	*Katampe*	*100*	*91*	*9*	*14*
	4 bedroom + BQ	*Katampe*	*53*	*60*	*33*	
	6 bedroom maisonette	*Katampe*	*835*	*800*	*4*	
	3 bedroom + BQ	*Katampe*	*90*	*70*	*22*	
	5 bedroom duplex	*Katampe*	*130*	*150*	*15*	
	12 unit 3 bedroom	*Katampe*	*720*	*800*	*11*	
	4 bedroom duplex	*Katampe*	*400*	*350*	*12*	
	4 bedroom	*Katampe*	*100*	*80*	*20*	
7	*3 bedroom flat + BQ*	*Wuye*	*45*	*43*	*4*	*10*
	3 bedroom	*Wuye*	*19*	*18*	*5*	
	5 bedroom duplex	*Wuye*	*230*	*235*	*2*	
	4 bedroom detached	*Wuye*	*170*	*150*	*11*	
	5 bedroom duplex	*Wuye*	*185*	*170*	*8*	
	3 bedroom apartment	*Wuye*	*85*	*60*	*29*	
	5 bedroom terrace	*Wuye*	*150*	*170*	*13*	
	6 bedroom	*Wuye*	*220*	*180*	*18*	
8	*5 bedroom duplex*	*Maitama*	*480*	*550*	*14*	*4*
	3 units 3 bedroom	*Maitama*	*600*	*625*	*4*	
	7 bedroom duplex	*Maitama*	*923*	*950*	*2*	
9	*3 bedroom*	*Jahi*	*49*	*45*	*8*	*8*
	4 bedroom apartment	*Jahi*	*40*	*45*	*12*	
	4 bedroom duplex	*Jahi*	*255*	*250*	*1*	
10	*3 bedroom*	*Garki*	*39*	*35*	*10*	*10*
	4 bedroom duplex	*Garki*	*235*	*200*	*14*	
	4 bedroom twin duplex	*Garki*	*410*	*400*	*2*	
11	*4 bedroom duplex*	*Galadimawa*	*115*	*130*	*13*	*11*
	5 bedroom flat	*Galadimawa*	*109*	*100*	*1*	
	5 bedroom	*Galadimawa*	*45*	*50*	*11*	
	4 bedroom	*Galadimawa*	*147*	*130*	*11*	
	3 bedroom duplex	*Galadimawa*	*55*	*45*	*18*	
	5 bedroom	*Galadimawa*	*50*	*45*	*10*	
12	*5 bedroom*	*Mabushi*	*400*	*420*	*5*	*5*
	4 bedroom terrace	*Mabushi*	*405*	*420*	*3*	
	5 bedroom + BQ	*Mabushi*	*445*	*420*	*5*	
	4 bedroom	*Mabushi*	*137*	*130*	*5*	
13	*3 bedroom*	*Gwarinpa*	*63*	*55*	*12*	*10*
	3 bedroom	*Gwarinpa*	*32*	*35*	*9*	
	5 bedroom semi-detached	*Gwarinpa*	*243*	*230*	*5*	
	3 bedroom bungalow					
	7 bedroom duplex	*Gwarinpa*	*63*	*60*	*4*	
	6 units 2 bedroom	*Gwarinpa*	*75*	*100*	*33*	
	4 bedroom bungalow	*Gwarinpa*	*227*	*250*	*10*	
	3 bedroom bungalow	*Gwarinpa*	*90*	*55*	*38*	
		Gwarinpa	*69*	*65*	*4*	
14	*3 bedroom*	*Kuje*	*22*	*18*	*18*	*10*
	3 bedroom	*Kuje*	*30*	*33*	*10*	

	5 be4droom	*Kuje*	*59*	*55*	*5*	
15	*2 bedroom*	*Lugbe*	*20*	*22*	*10*	
	3 bedroom bungalow	*Lugbe*	*47*	*30*	*36*	
	2 bedroom + BQ	*Lugbe*	*37*	*30*	*18*	
	3 bedroom bungalow	*Lugbe*	*45*	*40*	*11*	
	2 bedroom bungalow	*Lugbe*	*30*	*25*	*16*	
	3 bedroom bungalow detached	*Lugbe*	*33*	*35*	*6*	
16	*5 bedroom duplex + BQ*	*Lokogoma*	*60*	*90*	*50*	*50*
17	*4 bedroom*	*Gaduwa*	*27*	*30*	*11*	*11*
18	*4 bedroom terrace*	*Jabi*	*65*	*75*	*11*	*32*
	4 bedroom apartment	*Jabi*	*69*	*87*	*26*	
	3 bedroom	*Jabi*	*47*	*65*	*38*	
	3 bedroom	*Jabi*	*40*	*55*	*37*	
19	*4 bedroom semi detached*	*Apo*	*34*	*40*	*17*	*15*
	4 bedroom duplex					
	2 bedroom bungalow	*Apo*	*100*	*85*	*15*	
	9 bedroom duplex	*Apo*	*37*	*45*	*21*	
	3 bedroom duplex	*Apo*	*500*	*450*	*10*	
		Apo	*105*	*110*	*4*	
20	*3 bedroom duplex*	*Asokoro*	*165*	*120*	*27*	*8*
	4 bedroom flat	*Asokoro*	*400*	*370*	*7*	
	7 bedroom duplex	*Asokoro*	*490*	*600*	*22*	
	7 bedroom duplex	*Asokoro*	*900*	*940*	*4*	
	6 bedroom duplex	*Asokoro*	*900*	*900*	*0*	
	3 bedroom duplex	*Asokoro*	*110*	*120*	*9*	
21	*4 bedroom semi detached*	*Wuse*	*427*	*400*	*6*	*4*
	4 unit 3 bedroom flat on 2 floors	*Wuse*	*170*	*165*	*2*	
22	*17 unit 2 bedroom*	*Gwagwalada*	*215*	*200*	*6*	*6*
23	*3 bedroom bungalow*	*Kaura*	*83*	*60*	*28*	*28*
24	*3 bedroom bungalow*	*Karu*	*50*	*60*	*20*	*20*
25	*3 bedroom bungalow*	*Dakwo*	*27*	*24*	*11*	*11*
26	*6 unit 2 bedroom*	*Dawaki*	*60*	*70*	*16*	*10*
	5 bedroom duplex	*Dawaki*	*335*	*320*	*4*	

Bivariate regression analysis was carried out to assess the extent to which valuation could predict actual price in the residential property markets under study. In this instance, the independent variable is the valuer's valuation opinion while the dependent variable is the actual sale price of all residential property transactions in the study areas and the results are presented in Table 6.

Table 6: Result of the Regression Analysis

Residential Property Market	***Model***	***Unstandardised Coefficients***		***Standardised Coefficients***	***t***	R^2	***Adjusted*** R^2	***Sig***
		B	***Std Error***	***B***				
Minna	*(Constant)*	*1003636.524*	*1079871.461*		*.929*	*.876*	*.867*	*.370*
	Valuation	*.735*	*.077*	*.936*	*9.597*			*.000*
Abuja	*(Constant)*	*8166628.174*	*6212457.756*		*1.315*	*.937*	*.937*	*.191*
	Valuation	*.938*	*.023*	*.968*	*41.148*			*.000*

The regression equation for ascertaining the sale price from valuation opinion in the residential property market in Minna is

$$y = 1003636.52 + 0.735x + e \qquad (4)$$

In addition, the r squared for this equation is 0.876 which means 87.6% of the variance in sale price was predicted from valuation opinion with the remaining 12.4% being a result of chance or other *factors as indicated in Table 7. For the residential property market in Abuja, the regression equation is*

$$y = 81166628.20 + 0.938x + e \qquad (5)$$

Also, the r squared for this equation is 0.937. This implies that 93.7% of the variance in sale price was predicted from valuation opinion with the remaining 6.3% attributed to other factors. From the regression results, valuations are better proxies for actual prices in the residential property market in Abuja than Minna.

The respondents' opinions on the causes of valuation inaccuracy in the residential property market in Minna were evaluated through weighted mean and standard deviation. Inadequate time for proper inspection and valuation is ranked as the leading factor that causes inaccuracy as indicated in Table 7. Ranked second is ineffective regulatory framework and followed by usage of multiple valuation method and wrong valuation methodology. With a Cronbach Alpha of 0.890, these perceptions are reliable and acceptable. In the residential property market in Abuja, wrong valuation methodology is perceived as the leading cause of valuation inaccuracy and is ranked first as shown in Table 7. Ranked second and third are poor expertise of the valuer and mis-description of the property. With a Cronbach alpha of 0.768, these perceptions are reliable and acceptable.

Table 7: Perceived Causes of Inaccurate Valuations in the Residential Property Markets in the Study Areas

Perceived Causes	Minna				Abuja			
	Sum	Mean	Std Dev.	Rank	Sum	Mean	Std Dev.	Rank
Complex nature of subject property	42	4.2	1.03280	4th	390	3.55	1.17025	13th
Wrong valuation methodology	44	4.4	0.51640	3rd	443	4.02	0.96152	1st
Client pressure	42	4.2	0.91894	4th	425	3.86	1.16112	4th
Inadequate time for proper inspection and valuation	47	4.7	0.67495	1st	404	3.67	1.10137	11th
Usage of multiple valuation methods	45	4.5	0.84984	2nd	369	3.35	1.19315	16th
Inadequacy of relevant data	42	4.2	0.78881	4th	417	3.79	1.05878	7th
Imperfect nature of the property market	40	4.0	1.05409	5th	414	3.76	1.06596	8th
Ineffective regulatory framework	45	4.5	0.52705	2nd	383	3.48	1.16313	14th
Non- adherence to valuation standards	42	4.2	0.78881	4th	402	3.65	1.05305	12th
Valuers' poor familiarity with property market	44	4.4	0.96609	3rd	404	3.67	1.11790	10th
Limited number of similar valuations undertaken	40	4.0	0.81650	5th	382	3.47	1.11462	15th
Valuers' poor compliance with ethical standards in valuation	39	3.9	1.10050	6th	421	3.83	1.04801	6th
Poor expertise and experience of the valuer	39	3.9	1.19722	6th	435	3.95	0.96152	2nd
Uncertainty in the national economy	40	4.0	0.94281	5th	411	3.74	1.05515	9th
Wrong measurement of subject property	42	4.2	0.63246	4th	422	3.84	1.11312	5th
Mis-description of the subject property	39	3.9	0.99443	6th	431	3.92	1.09320	3rd

Valuers' opinions on measures to mitigate valuation inaccuracy in the study areas were ranked as presented in

Table 8. Ranked first in Minna is compliance with valuation standards and guidelines manual which is closely followed by stricter enforcement of NIESV code of conduct. Ranked second is the creation of a databank for valuation which is in consonance with the ranking of respondents in Abuja property market. This is followed by improved IT pupillage and improved valuation education in tertiary institutions in third and fourth places, respectively. With a Cronbach Alpha of 0.776, these perceptions are reliable and acceptable. In Abuja, the creation of databank for valuation is ranked first. Ranked second and third are improved valuation education in tertiary institutions and improved valuation techniques. With a Cronbach alpha of 0.760, these perceptions are reliable and acceptable.

Conclusion And Recommendation

The ability of valuation to predict actual price is greater in the residential property market in Abuja (93.7%) than in Minna (87.6%). This outcome may be attributed to the higher frequency of property market transactions in Abuja than Minna. It also implies that when transactions occur frequently in a property market, valuers are more likely to access comparable evidence to perform valuations more accurately than in an inactive property market. The use of wrong valuation methodology is perceived to be the leading cause of inaccuracy in valuations in Abuja (M=4.02; SD=0.96152) while inadequate time for property inspection and valuation is perceived to be the main cause of valuation inaccuracy in Minna (M=4.7; SD=0.67495). Based on the findings of the study, these could be mitigated through the establishment of a national databank for valuations in the country as well as strict enforcement of valuation standards and code of ethical conduct by the regulatory authorities in the valuation profession.

Table 8: Suggested measures to valuation inaccuracy in the Residential Property Markets in the Study Areas

Suggested Measures	*Minna*				*Abuja*			
	Sum	*Mean*	*Std Dev.*	*Rank*	*Sum*	*Mean*	*Std Dev.*	*Rank*
Componentisation of property valuation	33	3.3	1.41814	8th	438	3.9818	0.91853	9th
Improved valuation education in tertiary institutions	41	4.1	0.87560	7th	473	4.30	0.73634	2nd
Compulsory attendance of CPD	43	4.3	0.67495	6th	441	4.00	0.98144	8th
Improved IT and pupillage training	45	4.5	0.52705	3rd	453	4.11	0.90596	7th
Improved syllabus and curriculum	44	4.4	0.51640	4th	459	4.17	0.86586	5th
Stricter enforcement of NIESV code of conduct	45	4.5	0.52705	2nd	430	3.9091	1.02756	10th
Compliance with valuation standards and guideline manual	46	4.6	0.51640	1st	467	4.24	0.85870	4th
Specialization within the valuation profession	44	4.4	0.84327	5th	416	3.7818	1.07841	11th
Refresher courses for practicing valuers	44	4.4	0.69921	4th	455	4.14	0.95281	6th
Creation of databank for valuation	45	4.5	0.52705	2nd	475	4.31	0.84519	1st
Improved valuation techniques	43	4.3	0.82327	6th	470	4.27	0.77707	3rd

References

Ajibola, M.O. (2010). Valuation inaccuracy: An examination of causes in Lagos metropolis. Journal of Sustainable Development, 3 (4), 187-192. doi:10.5539/jsd.v3n4p187

Aliyu, B.A., Sani, H., Usman, H., & Muhammad, H. (2018). Ranking the causative factors of mortgage valuation inaccuracy in Kaduna metropolis. Real Estate Management and Valuation, 26 (3), 71-81. Doi: 10.2478/remav-2018-0026

AP1 (2012). Australia and New Zealand property and valuation standards. Retrieved from www.api.org on Wednesday 17th August, 2015.

Ayedun, C., Ogunba, O., & Oloyede, S. (2010). The accuracy of Nigerian property valuations revisited. Built

Environment Journal, 7 (2), 1-11.

Ayedun, C., Durodola, D.O., Oloyede, S.A., Akinjare, O.A., & Oni, S. A. (2018). An empirical evaluation of the factors militating against valuation accuracy in Nigeria. International Journal of Civil Engineering and Technology, 9(8),752-762.

Babawale, G. K. (2006). The growing concern over valuation accuracy in Nigeria. Journal of Land Use and Development Studies, 2 (1).

Babawale, G.K. & Omirin, M.M. (2011). Valuers and valuation firms' characteristics as causes of inaccuracy in valuation in Nigeria. Mediterranean Journal of Social Sciences, 2(3),12 – 23. Doi:10.5901/mjss. 2011.v2n3p12

Babawale, G.K. & Ajayi, C. A. (2011). Variance in residential property valuation in Lagos, Nigeria. Property Management, 29 (3), 222 - 237 Permanent link to this document: http://dx.doi.org/10.1108/02637471111139400

Babawale, G.K. (2021). Real estate valuation: Principles and methods. University of Lagos Press and Bookshops Ltd, Akoka, Yaba – Lagos.

Baum, A., Crosby, N., Gallimore, P., McAllister, P., & Gray, A. (2000). The Influence of valuers and valuations on the workings of the commercial property investment market. Report for the Education Trust of the Investment Property Forum, Jones Lang Laselle and Royal Institution of Chartered Surveyors, London.

Bretten, J., & Wyatt, P. (2001). Variance in commercial property valuations for lending purposes: an empirical study. Journal of Property Investment and Finance, 19 (3), 267-282.

Cannon, E.S., & Cole, A. R. (2011). How accurate are commercial real estate appraisals? Evidence from 25 Years of NCREIF sales data. Journal of Portfolio Management, 35(5), 68-88. Doi: 10.2139/ssrn.1824807

Effiong, J. B., & Mendie, A. E. (2019). A comparative analysis of valuation and sales price of residential properties in Calabar metropolis. International Journal of Scientific and Engineering Research, 10 (6), 219

IVSC (2022). International Valuation Standards. London: International Valuation Standards Council

Kilpatrick, A. J. (2007). Valuation of brownfield properties: Mathew Benders brownfield law and practice, University of Vermont Press

Kinnard, W. N., Lenk, M., & Worzala, E. (1997). Client Pressure in the commercial appraisal industry: How prevalent is it? Journal of Property Valuation and Investment, 15(3), 233-244.

McAllister, P. (1995). Valuation accuracy: A contribution to the debate. Journal of Property Research, 12 (3), 203-216. DOI: 10.1080/09599919508724145

Oduyemi, O., Okoroh, M., & Fajana, O. (2016). Property valuation inaccuracy in commercial office buildings: Establishing the key causative factors. International Journal of Real Estate Studies, 10 (1)

Olayonwa, G.O. (2006). Property valuation. Iwo: DPC Debo Company

Parker, D. (1999). Valuation Accuracy: An australian perspective. Paper presented at the 4th Pacific Rim Real Estate Society Conference held at Perth, Australia, January 19 - 21.

Reinert, J. (2020). Valuation accuracy across Europe: a mass appraisal approach. Journal of Property Research, DOI: 10.1080/09599916.2020.1837209

Biosensor Re-design requirements for Operational Facility Management in the Post-COVID workplace

Ataguba, J. O.
Department of Estate Management and Valuation, The Federal Polytechnic Idah, Nigeria
joataguba@fepoda.edu.ng;(ORCID: 0000-0001-7607-7563)

Abstract:

The post-COVID era presents a challenge of conceptually re-designing the erstwhile lab-compatible biosensor that can possibly detect the presence and concentration of the coronavirus but this time, at the workplace especially where facility users cannot perform specific activities or delivery specialist services based on the "Work-from-home" model. This study deploys aspects of design research to suggest the features that a facility manager expects to be incorporated in the re-design of bio-sensing system for the detection of COVID-19 in the workplace. For the re-design of a prototype COVID-19 biosensor, the study explored alternative system architecture, block diagram, and simple circuit diagrams respectively using diagramming and visual modelling software comprising Microsoft Visio, and Enterprise Architect. The Unified Modelling Language (UML) activity diagram in Enterprise Architect was used to explain the interrelationships and function of each component in the biosensor circuit diagram. It was found that the re-design of COVID-19 biosensors for workplace management solutions should basically include components such as an enhanced bio-receptor, enhanced bio-transducer, a high-gain amplifier system, micro- or nano processor, internal memory, display unit, and possibly a USB or Bluetooth interface to facilitate data exchange with an organization's mainframe computer. Beyond this conceptual design addressed in this study is a recommendation of interdisciplinary collaboration leading to the development, testing and evaluation of the prototype workplace-compatible COVID-19 biosensor.

Keywords: *Workplace, Facility Management, Biosensor, Design requirements, COVID-19, post-COVID.*

Introduction

Disease outbreaks and spread within an organization presents not just health and environmental concern but a major workplace productivity concern for the facility manager (Atkin & Brooks, 2009), to the extent that the agility of the facility manager is called to question. The outbreak of the novel coronavirus disease (nCOVID-19) was greeted with shock and anxiety among the human race worldwide. The restriction in human movement arising from the spread of the coronavirus, subsequent hospitalization of infected persons, self- and prescribed quarantine measures, partial and total lock down measures, as well as closure of international borders by countries around the globe culminated into temporal and permanent job losses, hardships for households, and economic recession (Amzat *et al.*, 2020; Kaushik & Guleria, 2020). The contagious nature of the infection was rapid because humans value social interaction, which often involve touch and physical contact (Amzat *et al.*, 2020). This is where the virus took advantage to spread rapidly, such that governments had to compulsorily respond by instituting various measures of lock down, 'physical' distancing and restriction of movement. After over 1,020 days since the World Health Organization (WHO) declared the novel coronavirus disease (COVID-19) outbreak as an international public health emergency, virtually all countries across the globe had developed resilience to the virus, embraced vaccination and quarantine services, while the scientific communities continue to evolve healthcare and workplace solutions to deal with the aftermath of the pandemic and prepare for possible occurrence of similar pandemics in the near future (Ling & Tam, 2022). Some corporate organizations had to stop operations, whereas others had to alter their model of workplace operations in response to the COVID-19 pandemic by instantiating the work-from-home model although with opportunities of increased demand for mobile and ubiquitous computing (Hou *et al.*, 2021), and the cons of distractions at home (Kaushik & Guleria, 2020). A number of corporate organizations were reported to have responded to the pandemic by acquiring smart monitoring technologies for facility management (FM) (Lundberg, 2022), which can be construed as a dimension of change management for workplace facility operations.

Change is one of the issues that facility managers from the operational-, tactical-, and strategic domains would have to deal with (Atkin & Brooks, 2009; Barret & Baldry, 2003). For instance, Duffy (2000) had envisioned how technological changes driven by a synergy between facilities managers and designers of facility services would continue to evolve in the light of beneficial innovation, especially in offices/workplaces. In about two decades from these findings is the reality of health risks posed by the coronavirus infections, which now warrants a call for the re-design and upgrade of sensors which had hitherto served as the precursors for facility diagnostics and the automation of workplace operations respectively.

A sensor as an electronic device that detects and measures the occurrence of a natural phenomenon, which it subsequently transmits as input data to a main control system for storage, retrieval, and processing (Kumar *et al.*, 2021; Teja, 2021). Most sensors come in the form of chip-embedded devices with microprocessors, circuits, and specially crafted components designed to function like the human organs such as the eyes (camera), the ears (microphone or noise detector), the nose (smoke detector), and the skin (touch-, thermal- and thermal infrared sensors) among others. Besides their cognitive significance in technology products, sensors are constituents of computer systems, which observe, measure and transmit data for onward decision-making by the data user. Among the sensors that require upgrade from a laboratory-compatible format to a workplace compatible format is the COVID-19 biosensor.

Biosensor otherwise called biomedical sensor in some cases (Neuman, 2000), is an electronic device that detects the presence of- and measures the concentration of chemical, organic- and by-products of organic matter in the human body or in an environment including the measurement of antibodies arising from infections (Samson *et al.*, 2020; Smith, 2000), so that the knowledge of the presence of disease causing pathogens could be established (Kumar *et al.*, 2021; Mohankumar *et al.*, 2021; Singh *et al.*, 2014). According to Samson *et al.* (2020) and Souf (2016), electronic biosensors for coronavirus detection should be designed as sensitive, agile, cheap, and portable alternatives to the conventional laboratory testing methods for the virus. This is likened to matching sensor upgrade with the current risk confronting the workplace (Teicholz, 2004). At this instance is the matching of viral biosensor re-design with the existing risks of COVID-19 in the workplace; more so that the continuous mutation of the virus shall equally yield detectable analytes in the workplace.

The contemporary dimension of managing the workplace environment in a post-COVID era requires ideas that could tailor biosensor re-design towards mitigating risks associated with the spread of coronavirus and the loss of significant staff strength arising from COVID-19 complications; especially when certain workplace activities and services delivery are rigid and cannot be handled using the "Work-from-home" model. The overarching question is: What are the basic features that a facility manager should suggest for incorporation in the re-design of bio-sensing system for the detection of COVID-19 in the workplace?

The essence of this article is to challenge the stakeholders in the design and manufacture of sensors with the task of developing new generation of biosensors capable of scanning air quality and detecting the concentration of airborne disease pathogens especially the coronavirus as the trajectory for the perfection of COVID test kits continue to advance.

Review of Literature

Operational workplace FM in the Post-COVID era

The workplace or operating environment of an organization is the main object of FM practice (Tuomela & Phuto, 2001). Workplace can be defined as a typical office or workshop environment where products and services are created and packaged to the benefits of the end-users. The typical occupants of the workplace might include the employer and the employees as well as the customers/end-users who might visit the same operating environment in pursuit of specific products and services. Springer (2004) underscored the need for the workplace to be designed and configured to meet the needs of the users of the built facility and services therein if desirable performance and productivity of the organization is to be realized. Among the indicators of enhanced workplace productivity arising from deployment of operational FM include employee comfort and motivation (David, 2006), which depends on a consideration of health and related environmental issues, more so that the emergence of COVID-19 and its daunting consequences on office environment remains a reality that confronts all organizations irrespective of their size and scale of production/services.

There has been an array of observable changes in the way most organizations manage their core- and ancillary/support services following the advent of COVID-19 and subsequent transition from that era. Among these changes identified by Kaushik and Guleria (2020) is the increased sensitivity of organizations to hygiene and "social distancing" at workplace such that staff might have to adhere to schedules instructing them to work from the home on specific days and report to the workplace on other days when it is obvious that certain tasks cannot be handled at home. In Turkey, Tanrıvermiş (2020) envisioned how an array of emerging technologies including Prop-tech, Internet of things (IoT), and blockchain, among others might likely change the practice of facility-and real estate management in the Post-COVID era. From the perspective of FM in the manufacturing sector, Diaz-Elsayed *et al.* (2020), reiterated that the COVID-19 era ushered in higher demand for safer work environments for employees. Diaz-Elsayed *et al.* (2020) equally observed an increased interest of manufacturers for automation of operations, but with attendant consequences for the re-training of the workforce. In other words, it shall be counterproductive for an organization to procure automated facilities and infrastructure without a corresponding training of functional units' personnel on how to operate them optimally.

Hou *et al.* (2021) provided an account of how functional units in most organizations responded to the external force exerted by the COVID-19 pandemic by deploying digital technologies in the delivery of facilities services. On their own part, Tanpipat *et al.* (2021) recommended that facility managers should adapt organizational facilities to the vagaries of technological- and global economic changes if remote working is desirable.

Conducting a study on the readiness of FM organizations in Singapore to respond to changes presented by the COVID-19 pandemic, Ling and Tam (2022) found that majority of the FM organizations exhibited agility in services delivery by responding swiftly to the challenges posed by the pandemic through a coordinated management of employee's/occupants' health, and flexibility of operations. In a related study, Chua *et al.* (2022) recommended that facilities managers should respond to the paradigm shift posed by COVID-19 since most organizations were confronted with challenges of design and re-configuration of open office layout, congregation spaces and hot desk relocations.

A common factor in the review of these studies is the important place that is accorded the upgrading of existing stock of smart technologies-, diagnostics-, and ICT infrastructure aimed at improving the agility and resilience of workplaces to deal with emerging dimensions of facilities operations in pandemic and post-pandemic eras. Forming the bedrock for the upgrade of these tools is an evaluation and re-design of biosensors and other related sensors embedded in the interactions between people and the workplace, among which include biosensors for the detection of airborne analytes from nCOVID-19 or SARS-Cov2.

Existing- and envisaged developments in workplace-compatible COVID-19 biosensors

There has been an array of efforts towards the design and development of biosensors for the detection of human respiratory viruses in the past. These biosensors can be classified into four from the perspective of their technologies to include Optical biosensors, Electrochemical biosensors, Piezoelectric biosensors, and Thermal biosensors (Saylan *et al.*, 2019; Souf, 2016). The trajectory for the development of respiratory virus detection biosensors started with the discovery of the *Swine Influenza* virus and took an advanced dimension following the advent of the *severe acute respiratory* *syndrome* (SARS-CoV). Souf (2016) provided a tabulated summary (See Table 1) of these biosensors and the specific viral analytes that were targeted for detection.

Advances in sensing technologies for respiratory viral infections comprised the erstwhile gene-editing biological sensor coupled with a *graphene*-based Field Effect Transistor (*FET*) used initially for the nCOVID-19 test (Hajian *et al.*, 2019), and the Fluorine Doped Tin Oxide (*FTO*) electrode biosensor device that can possibly return COVID-19 test results in about 10 to 30 seconds (Mahari *et al.*, 2020). Other categories of COVID-19 bio-sensing technologies include Plasmonic photothermal biosensor, Wearable sensors, Nanosensors, Cell-based biosensors, and the Immunosensor (Behera *et al.*, 2020). In addition to these is the dual-functional Plasmonic sensor, which was found to exhibit optimal level of sensitivity in the detection of coronavirus (Qiu *et al.*, 2020).

Table 9: Advances in biosensors for respiratory virus detection

Type of portable biosensor	Target virus	Analyte to be recognized	Other viruses detected
Electrochemical Bio/Immunosensor	Influenza A Virus	M1 protein	Parainfluenza; Rhinovirus; Middle East respiratory syndrome coronavirus (MERS); severe acute respiratory syndrome (SARS-CoV)
Optical Bio/Immunosensor	MERS	Recombinant Spike protein S1 (Human betacoronavirus 2c EMC/2012)	SARS-CoV; H5N1 influenza virus; Human Adenovirus; Respiratory Syncytial Virus (RSV)
Piezoelectric immunosensor	SARS-CoV	Spike protein S1	Influenza Virus; Adenovirus; RSV; MERS
Thermal biosensor	SARS-CoV	RNA-dependent RNA polymerase (*RdRp*) gene	MERS; SARS-CoV-2

Source: Souf (2016)

Samson *et al.* (2020) suggested that the development of portable rapid-response biosensors should incorporate signal reporting agents capable of identifying nCOVID-19 analytes or biomarkers in a single step. Among these suggested rapid-response biosensors include the nano scale electrochemical-based DNA-sensing device, the automated DNA nanoswitch biosensor (Zhou *et al.*, 2020), and the isothermal COVID-19 biomarker identifier and amplifier (Jung *et al.*, 2016). However, all these aforementioned devices are mostly laboratory-based sensors that would require the use of *oropharynx* test swabs to draw samples from recipients of voluntary nCOVID-19 tests.

Proximate insights into the development of workplace-compatible biosensor for the detection of COVID-19 could be drawn from similar design-oriented studies credited to Villagrasa *et al.* (2013), Mahari *et al.* (2020), and Raja (2021). Villagrasa *et al.* (2013) on their part, provided insight into circuit configurations of Amperometric Biosensors used to detect and monitor disease pathogens. In a related study, Mahari *et al.* (2020) improved on the circuitry configuration of a prototype COVID-19 biosensor developed mainly for clinical use through the incorporation of a 16 x 2 character LCD display in tandem with a similar bio-sensing device designed, developed, and tested by Raja (2021). Common to the works of Mahari *et al.* (2020) and Raja (2021) was the incorporation of ARDUINO®, a microprocessor board which receives input signals from an Amplifier and serves as connection port for USB, Bluetooth, data storage, and display devices. These recent developments in COVID-19 sensing devices have provided a ray of possibilities for the deployment of similar technologies that will enable the facilities manager to track and control COVID-19 and other infectious viral respiratory diseases in the workplace.

Conceptual frameworks for COVID-19 biosensor (re) design

The building block for the design and development of sensors, including the workplace-compatible COVID-19 biosensor presented in this article can be traced to the ground work of Stillings *et al.* (1995)

regarding cognitive architecture. As indicated in Figure 1, this cognitive architecture is designed to mimic an instance or collection of the human sensory organ.

The sensory component in Figure 1 is designed to sense the presence of a measurand/analyte and then transmit it as signal to the central processing system which mimics the human brain. It is at this stage that memory, learning, and languages are deployed to make judgement, inference, and decision regarding the measurand.

This simple explanation underlies the working principle of a workplace-compatible COVID-19 biosensor. Just as in the case of Mahari *et al.* (2020) where instantiated version of this architecture was featured in the flow chart of a prototype COVID-19 sensor developed for clinical use, the fundamental architecture for sensory systems in Figure 1 was adopted for the purpose of the biosensor re-design in this article.

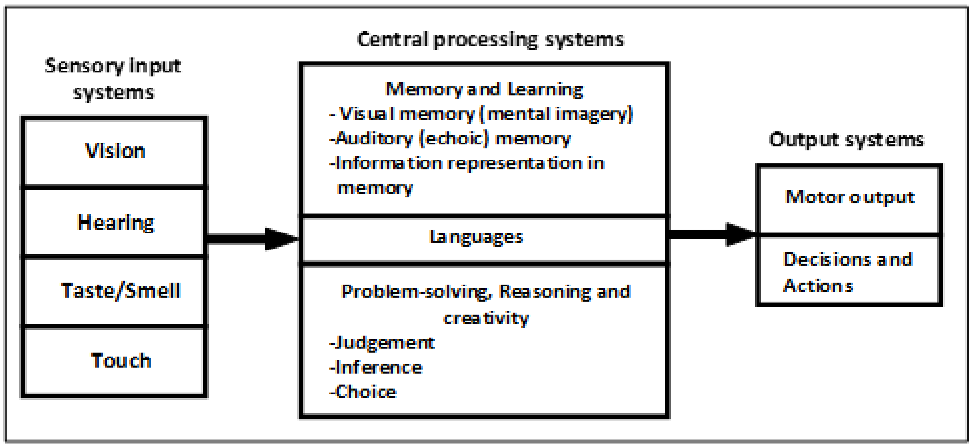


Figure 1: Cognitive architecture
Source: Stillings et al. (1995). *Cognitive Science: An Introduction* (2nd ed.). Cambridge, MA: The MIT Press.

Recalling the insights provided by Atkin and Brooks (2009), Riaz, Parn, Edwards et al. (2017), and RICS and IFMA (2018), regarding the importance of health, safety and environment in FM and allied practices, and the heightened call for the deployment of smart FM technologies in response to the COVID-19 pandemic (Lundberg, 2022; Sakar, 2021; Sampaio *et al.*, 2022; Tanrıvermiş, 2020; Xie *et al.*, 2021), it is appropriate at this juncture, to challenge the stakeholders in biotechnology and engineering with the task of developing a new generation of COVID-19 biosensor that is compatible for use within the workplace.

Materials And Methods

Research Philosophy and paradigm

This Ontological-realist study presented the researcher's conception of individual bio-sensing components that could be assembled to automatically detect and report the presence and concentration of COVID-19 and/or its analytes in the workplace. Just as an Architect designs a building on paper for onward construction by the builder and the construction team on site, this article is proposing the re-design of a biosensor for the detection of COVID-19 in the workplace environment using modelling and conceptual toolkits, so that stakeholders from multidisciplinary fields of biotechnology and computer engineering would be challenged to construct applicable bio-sensing components and couple them to offer workplace-based solutions in that regard.

Methodology

This study is anchored on specific aspects of the design research technique, which Çağdaş and Stubkjær (2011) defined as the processes for the (re)development of an artefact that can be used to solve an existing problem. The artefact in this case is a workplace-compatible nCOVID-19 biosensor; whereas the existing problem to be solved is the identification of the presence and concentration of COVID-19 within the workplace. The aspects of design research addressed for the purpose of this study include analysis of existing situation of a typical COVID-19 biosensor, analysis of biosensor requirements, and the design of biosensor architecture and component specification, so that future design researches on the subject shall address the other aspects of comprising biosensor development, testing, and evaluation.

Materials and biosensor requirements

Drawn from the existing works of Grieshaber *et al.* (2008), Villagrasa *et al.* (2013), Mahari *et al.* (2020), and Raja (2021), are the symbolic objects for the re-design of COVID-19 biosensor to fit within the workplace environment comprising resistors, diode, high gain amplifier, resistors, capacitors, transducer, a bio-receptor/sensing diode, 16 x 2 character LCD screen, and an on-board processor. The minimum configuration for the on-board processor should include interfaces for Bluetooth, USB, memory module, and LCD displays.

Hardware configuration for biosensor re-design

The re-design of a workplace-compatible COVID-19 biosensor in this article was instantiated using computer system with hardware configuration contained in Table 2. The minimal processor configuration in Table 2 is chosen to facilitate speedy launch and operation of the sensor re-design software packages.

Table 10: Minimum hardware component and configuration

Hardware component	Minimum configuration
CPU	Intel® 2.30GHz Corei7-360QM CPU OR 3.6GHz AMD® Ryzen 1800X CPU OR Equivalent
System memory	8GB RAM
Hard Drive	500 GB
Optimal size of VDU	17 inches TFT screen
Operating system	Windows 7, 64 bit

Software specification for biosensor re-design

Indicated in Table 3 are the software packages that were used to re-design a prototype workplace-compatible COVID-19 biosensor. Microsoft® Word® 2007 was used to re-design the Architecture- and block diagram of a typical nCOVID-19 sensor in Figures 2 and 3 respectively; whereas Microsoft® Visio® 2007 was used to re-design the circuit diagram of the proposed nCOVID-19 sensor.

Table 11: Software specification for biosensor re-design

Software	Minimum specification
Word Processor	Microsoft® Word® 2007
Diagramming tool	Microsoft® Visio® 2007
Visual Modelling and Design tool	Enterprise Architect® 7.1

Technique of data presentation and analysis

Image-oriented data were generated in the course of re-designing a prototype workplace-compatible COVID-19 biosensor. These images were presented in the form of Figures. Subsequently, the Unified Modelling Language (UML) activity diagram tool in Enterprise Architect® 7.1 was used to structure the interrelationships among the components of the proposed biosensor as contained in the block- and circuit diagrams in order to avert redundancy in the discussion of the three deliverables of the biosensor re-design in Figures 2, 3, and 4 respectively. In tandem with the UML activity diagram in Figure 5 was a text-based description of the content of- and synergy among the deliverables of the biosensor re-design.

Results and Discussion

A prototype nCOVID-19 Biosensor Architecture

Prototype of workplace-compatible COVID-19 sensor was conceived in the architecture in Figure 2 alongside the basic system components, and the flow of data across these components.

The input sensory system highlighted with a magnifying lens in Figure 2 features the bio-receptor and bio-transduction components in the system. The simple deduction from the architecture in Figure 2 is that the sensory input system detects the presence and concentration of COVID-19 in the workplace and forwards the sensed data to a microprocessor which processes and stores the data, for onward retrieval and display

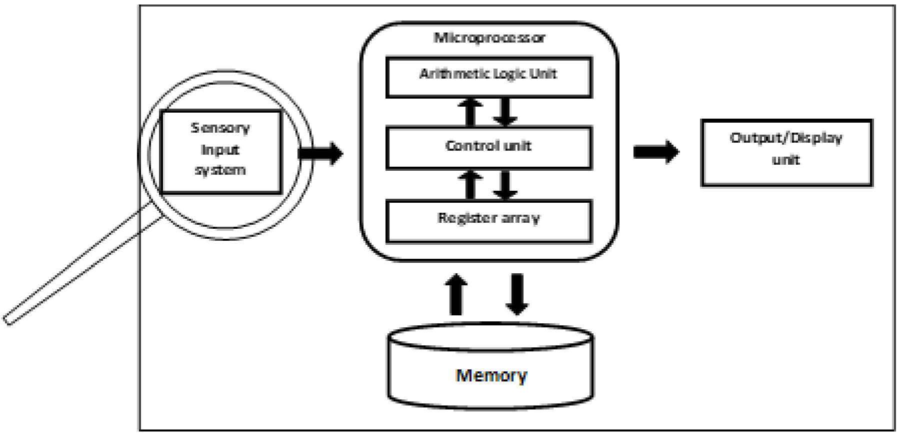


Figure 2: Architecture of a typical nCOVID-19 sensor
Source: Authors conception

A prototype block diagram for nCOVID-19 biosensor

The idea presented in Figure 3 is similar to that in Figure 2 except that Figure 3 envisions that the operation of the COVID-19 biosensor is driven by power supply input leading to viral analyte detection by a bio-receptor in the form of electric signals that undergo transduction before reaching the amplifier.

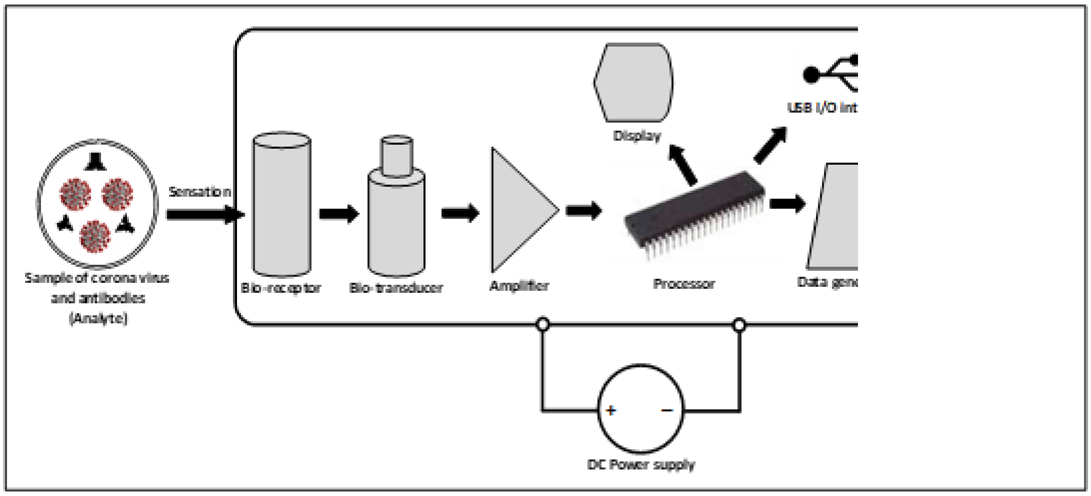


Figure 3: Block diagram of a typical nCOVID-19 sensor
Source: Authors conception

The amplified electric signals are further sent to a processor, which deploys the embedded learning and memory repository to measure, judge, infer, and make choices regarding the detected viral analyte. Just as in Figure 1, the output of this electronically-driven cognitive process in Figure 3 shall result in decision-making regarding the presence-, concentration, and risk of coronavirus infection within the workplace.

A typical nCOVID-19 Biosensor circuit diagram

The circuit diagram in Figure 4 was modelled after the architecture and block diagrams in Figures 2 and 3, but with insights from existing ground work on similar lab-compatible bio-sensing devices credited to Grieshaber *et al.* (2008), Villagrasa *et al.* (2013), Mahari *et al.* (2020), and Raja (2021) respectively. The materials included in the circuit diagram (Figure 4) include the bio-receptor, bio-transducer, amplifier system, onboard processor, memory storage, and display units respectively.

A detailed explanation of the working process of the sensor circuit (Figure 4) had been provided under the discourse of the Unified Modelling Language (UML) activity diagram in Figure 5.

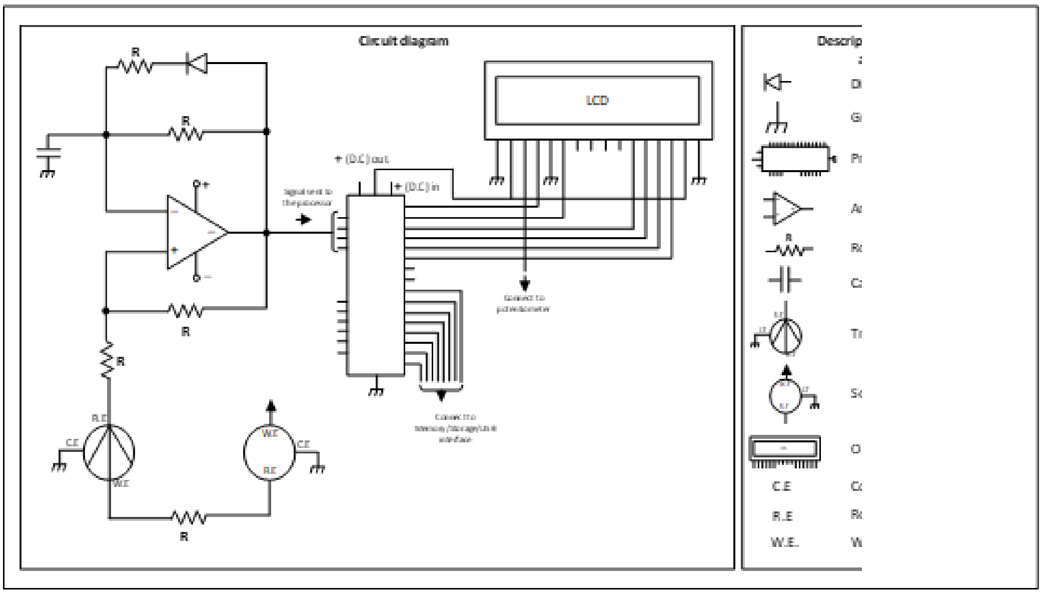


Figure 4: Simple circuit diagram of a prototype nCOVID-19 sensor
Source: Authors conception

A discourse of sensor workflow using UML activity diagram

The interconnected in the operations of components in the circuit of a workplace-compatible COVID-19 biosensor has been presented in the UML activity diagram in Figure 5. It is expected that the supply of 6 volts DC input power shall activate the working/sensing electrode (W.E) mounted on the bio-receptor to detect the presence of COVID-19 at a specific epoch through airborne analytes comprising enzymes, nucleic acids (DNA and RNA), viral proteins, actual viral particles, and antibodies emanating from infected persons, irrespective of their symptomatic attributes so that the output signal is passed on to a transducer through the reference electrode (R.E) of the viral biosensor for onward conversion into electrical signal (Guliy *et al.*, 2022). The transducer receives the sensed data from the bio-receptor through its own working electrode (W.E) and then measures the concentration of the viral elements it has sensed per volume of air for onward conversion to a specific energy level. This converted energy level from the measurement of the COVID-19 or its analytes are sent in real-time to an amplifier through the reference electrode of the transducer (R.E).

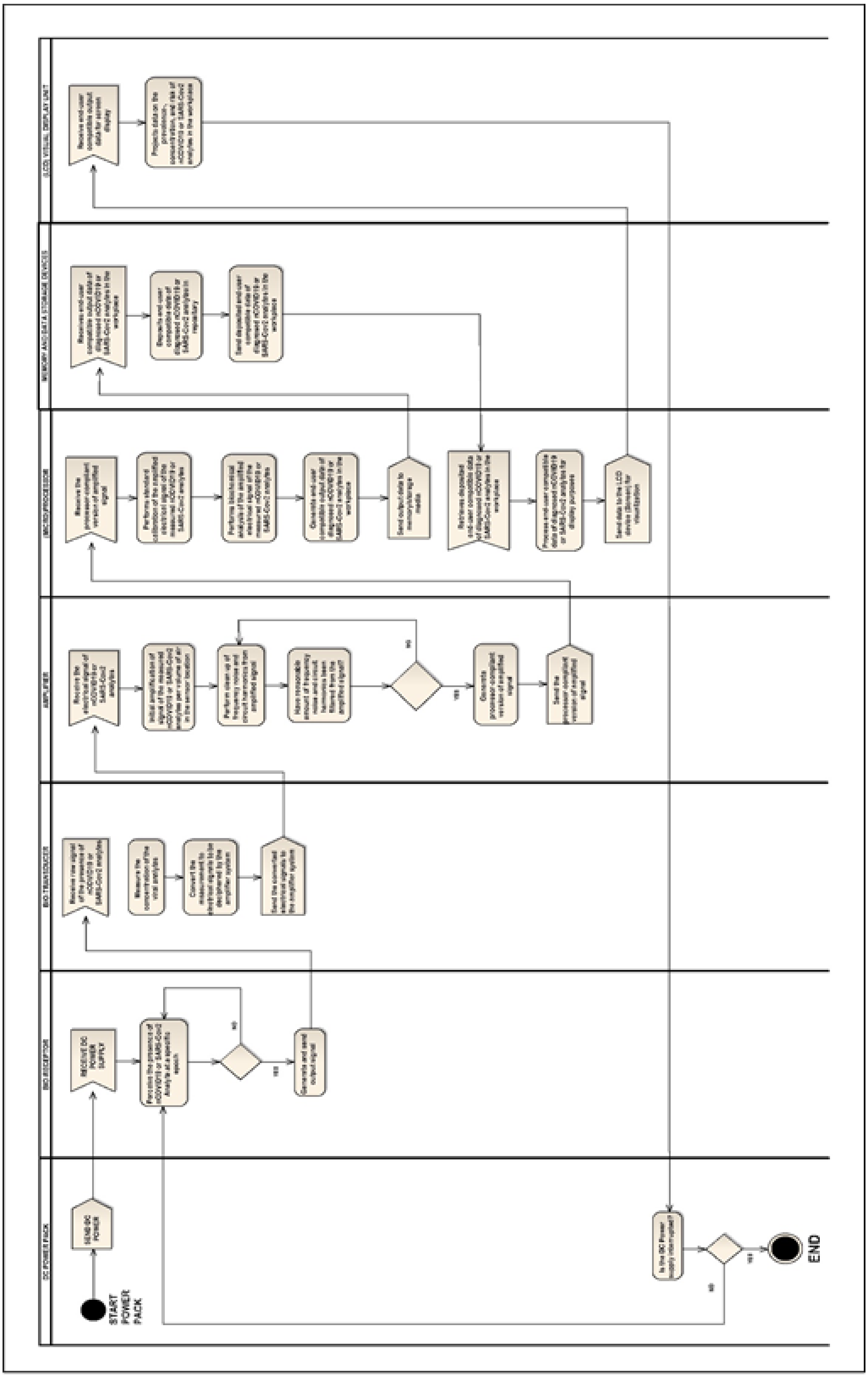


Figure 5: UML activity diagram of a prototype nCOVID-19 sensor
Source: Author's conception

The high-gain differential amplifier in Figure 5 receives the transduced signal and amplifies it in real time to reach the microprocessor. The capacitor on the amplifier feedback loop (Figure 4) should be incorporated in the device in order to clean up frequency noise and harmonics in the circuit (Villagrasa *et al.*, 2013). The high-gain signal of the sensed analytes is transmitted to a microprocessor, where it undergoes rapid recognition, standard calibration, and biochemical analysis aimed at generating actual outputs and data that are compatible with graphic user interfaces (GUIs) as well as computerized storage devices and media.

The deployment of an ARDUINO® board shall possibly avail the system with USB 2.0 or 3.0 output port and Bluetooth interface aimed at facilitating communication between the biosensor and the mainframe computer deployed in the workplace for operational FM.

The highest point of this automated workplace-oriented health cognitive system shall be the rapid screen visualization of the presence and concentration of COVID-19 in the workplace, as well as risk factor associated with the concentration of viral pathogens and its biomarkers. Although the simple circuit diagram in Figure 4 suggests the incorporation of Liquid Crystal Display (LCD), the re-engineering of the display technology might feature the use of interactive touch screens. The continuous supply of DC power shall guarantee the continuous operation of this device, so that bio-reception and data storage for each epoch of sampling performed on the airborne viral analyte would assist in operational FM within the workplace.

Expected Benefits of the Re-Designed Biosensor

The re-design of workplace-compatible COVID-19 biosensors is expected to assist operational facilities managers to control access to locations characterized by high risk of COVID-19 analytes within the organization.

Supporting the incubation and propagation of the coronavirus comprise air temperatures in the range of 5°C to 15°C (Huang *et al.*, 2020), which is prevalent with typical air-conditioning systems. Therefore, COVID-19 biosensor re-design within this context might facilitate the control of air temperatures at the workplace aimed at averting rapid incubation and spread of the virus.

Bearing in mind that social interaction and physical contact that might likely increase the risk of human-to-human airborne pathogens infection including COVID-19 is inevitable in the workplace (Luongo *et al.*, 2016; Rayegan *et al.*, 2023), it is expected that COVID-19 biosensor re-design would avail facility managers with tools to monitor indoor air quality within the workplace especially through the use of air purifiers and monitoring of facility users' compliance with health and safety practices.

Whereas the re-design of a workplace compatible COVID-19 biosensors shall avail the facility manager with the tool for real-time detection of air-borne pathogens within the workplace, such automated cognitive system could serve as a decision-support tool for occupancy control and re-scheduling of workers who shall work from the home to help decongest the workplace pending the attainment of a zero airborne pathogen concentration level. Similarly, the facility manager can use this sensor to optimize the number of persons working and visiting the workplace over a given period of time.

The re-designed workplace-compatible COVID-19 biosensors might possibly avail the facility manager with a technology-driven tool to detect the core and ancillary footprints of COVID-19 that are beyond the bandwidth of existing bio-receptors, so that early diagnosis and treatment of an infected employee could be instantiated. The COVID-19 biosensor re-design shall further facilitate the configuration of sitting arrangements, operational assets, and services of an organization in compliance with post-COVID safety measures, especially for laboratory- and workshop-based tasks that cannot be performed at home by the employees in violation of workplace safety and ethics.

The design and possible development of this sensor shall facilitate the analysis and reportage of COVID-19 data for specific locations in the workplace so that the operational facility manager can enforce scheduled- or emergency workplace sanitation and fumigation (Kaushik & Guleria, 2020), shut down of high-risk office partitions, automation of hand washing facilities, and zero tolerance for nasal and/or oral droplets from employees (Hou *et al.*, 2021), among other control measures.

Conclusion

Majority of the existing prototype biosensors for the detection of COVID-19 were built specifically for laboratory testing, and are unsuitable for workplace solutions at the operational FM level. Just like the laboratory-based COVID-19 biosensors, the re-design of COVID-19 biosensors for workplace management solutions should include components comprising an enhanced bio-receptor, enhanced bio-transducer, a high-gain amplifier system, micro- or nano- processor, internal memory, display unit, and possibly a USB interface to facilitate data exchange with an organization's Facility Management mainframe. Adequate data training is recommended for the prototype COVID-19 biosensor before commercial deployment to end-users, so that mutated variants of the coronavirus can be effectively detected; whereas collaborations from multidisciplinary fields comprising virology, biotechnology, biochemistry, medicine, electrical- and computer engineering (Grieshaber *et al.*, 2008), among other scientific fields would be required to translate the conceptual ideas of the facility manager from artefact design to the development, testing and evaluation of the prototype COVID-19 biosensor for onward deployment within the workplace. The development and assembly trajectory of this artefact could be approached from the nano scale, given the continuous advancement in bio-sensing technologies and the quest for a pandemic-resilient workplace in the future.

References

Amzat, J., Aminu, K., Kolo, V. I., Akinyele, A. A., Ogundairo, J. A., and Danjibo, M. C. (2020). Coronavirus outbreak in Nigeria: Burden and socio-medical response during the first 100 days. *Int J Infect Dis, 98*, 218-224. doi: 10.1016/j.ijid.2020.06.067

Atkin, B., and Brooks, A. (2009). *Total Facilities Management.* (3rd ed.). Chichester: Wiley Blackwell.

Barret, P., and Baldry, D. (2003). *Facilities Management: Towards Best Practice.* Oxford: Blackwell.

Behera, S., Rana, G., Satapathy, S., Mohanty, M., Pradhan, S., Panda, M. K., Ningthoujam, R., Hazarika, B. N., and Singh, Y. D. (2020). Biosensors in diagnosing COVID-19 and recent development. *Sensors International, 1*, 100054. doi: https://doi.org/10.1016/j.sintl.2020.100054

Çağdaş, V., and Stubkjær, E. (2011). Design research for cadastral systems. *Computers, Environment and Urban Systems, 35*(1), 77-87. doi: 10.1016/j.compenvurbsys.2010.07.003

Chua, S. J. L., Myeda, N. E., and Teo, Y. X. (2022). Facilities management: towards flexible work arrangement (FWA) implementation during Covid-19. *Journal of Facilities Management, ahead-of-print*. doi: 10.1108/JFM-09-2021-0101

David, M. (2006). *The A-Z of facilities and property management* (2nd ed.). London: Thorogood.

Diaz-Elsayed, N., Morris, K. C., and Schoop, J. (2020). Realizing Environmentally-Conscious Manufacturing in the Post-COVID-19 Era. *Smart Sustain Manuf Syst, 4*(3), 314 - 318. doi: 10.1520/ssms20200052

Duffy, F. (2000). Design and facilities management in a time of change. *Facilities, 18*(10/11/12), 371 - 375. doi: 10.1108/02632770010349592

Grieshaber, D., MacKenzie, R., Vörös, J., and Reimhult, E. (2008). Electrochemical Biosensors - Sensor Principles and Architectures. *Sensors (Basel), 8*(3), 1400-1458. doi: 10.3390/s80314000

Guliy, O. I., Zaitsev, B. D., Smirnov, A. V., Karavaeva, O. A., and Borodina, I. A. (2022). Prospects of acoustic sensor systems for antibiotic detection. *Biosensors and Bioelectronics: X, 12*, 100274. doi: https://doi.org/10.1016/j.biosx.2022.100274

Hajian, R., Balderston, S., Tran, T., deBoer, T., Etienne, J., Sandhu, M., Wauford, N. A., Chung, J.-Y., Nokes, J., Athaiya, M., Paredes, J., Peytavi, R., Goldsmith, B., Murthy, N., Conboy, I. M., and Aran, K. (2019). Detection of unamplified target genes via CRISPR–Cas9 immobilized on a graphene field-effect transistor. *Nature Biomedical Engineering, 3*(6), 427-437. doi: 10.1038/s41551-019-0371-x

Hou, H., Remøy, H., Jylhä, T., and Vande Putte, H. (2021). A study on office workplace modification during the COVID-19 pandemic in The Netherlands. *Journal of Corporate Real Estate, 23*(3), 186-202. doi: 10.1108/JCRE-10-2020-0051

Huang, Z., Huang, J., Gu, Q., Du, P., Liang, H., and Dong, Q. (2020). Optimal temperature zone for the dispersal of COVID-19. *Sci Total Environ, 736*, 139487. doi: 10.1016/j.scitotenv.2020.139487

Jung, I. Y., You, J. B., Choi, B. R., Kim, J. S., Lee, H. K., Jang, B., Jeong, H. S., Lee, K., Im, S. G., and Lee, H. (2016). A Highly Sensitive Molecular Detection Platform for Robust and Facile Diagnosis of Middle

East Respiratory Syndrome (MERS) Corona Virus. *Adv Healthc Mater, 5*(17), 2168-2173. doi: 10.1002/adhm.201600334

Kaushik, M., and Guleria, N. (2020). The Impact of Pandemic COVID -19 in Workplace. *European Journal of Business and Management, 12*(15), 9 - 18.

Kumar, K., Sharma, A., and Tripathi, S. L. (2021). Sensors and their application. In S. L. Tripathi, V. E. Balas, S. K. Mohapatra, K. B. Prakash & J. Nayak (Eds.), *Electronic Devices, Circuits, and Systems for Biomedical Applications* (pp. 177 - 195): Academic Press.

Ling, F. Y. Y., and Tam, J. Y. (2022). Agility of facilities management organizations during the COVID-19 pandemic: lessons learnt for future pandemics. *Facilities, 40*(13/14), 862-878. doi: 10.1108/F-02-2022-0032

Lundberg, B. J. (2022). Smart Monitoring in a Post COVID-19 Office. Retrieved 26th December, 2022, from https://facilitymanagement.com/smart-monitoring-post-covid-19/

Luongo, J. C., Fennelly, K. P., Keen, J. A., Zhai, Z. J., Jones, B. W., and Miller, S. L. (2016). Role of mechanical ventilation in the airborne transmission of infectious agents in buildings. *Indoor Air, 26*(5), 666-678. doi: 10.1111/ina.12267

Mahari, S., Roberts, A., Shahdeo, D., and Gandhi, S. (2020). eCovSens-Ultrasensitive Novel In-House Built Printed Circuit Board Based Electrochemical Device for Rapid Detection of nCovid-19 antigen, a spike protein domain 1 of SARS-CoV-2. *bioRxiv*. doi: 10.1101/2020.04.24.059204

Mohankumar, P., Ajayan, J., Mohanraj, T., and Yasodharan, R. (2021). Recent developments in biosensors for healthcare and biomedical applications: A review. *Measurement, 167*, 108293. doi: 10.1016/j.measurement.2020.108293

Neuman, M. R. (2000). Biomedical Sensors. In R. C. Dorf (Ed.), *The Electrical Engineering Handbook* Boca Raton: CRC Press LLC.

Qiu, G., Gai, Z., Tao, Y., Schmitt, J., Kullak-Ublick, G. A., and Wang, J. (2020). Dual-Functional Plasmonic Photothermal Biosensors for Highly Accurate Severe Acute Respiratory Syndrome Coronavirus 2 Detection. *ACS Nano, 14*(5), 5268-5277. doi: 10.1021/acsnano.0c02439

Raja, G. B. (2021). Fingerprint-based smart medical emergency first aid kit using IoT. In S. L. Tripathi, V. E. Balas, S. K. Mohapatra, K. B. Prakash & J. Nayak (Eds.), *Electronic Devices, Circuits, and Systems for Biomedical Applications* (pp. 325 - 348): Academic Press.

Rayegan, S., Shu, C., Berquist, J., Jeon, J., Zhou, L., Wang, L., Mbareche, H., Tardif, P., and Ge, H. (2023). A review on indoor airborne transmission of COVID-19– modelling and mitigation approaches. *Journal of Building Engineering, 64*, 105599. doi: https://doi.org/10.1016/j.jobe.2022.105599

RICS, and IFMA. (2018). *Procurement of facility management: RICS professional statement*. London: Royal Institution of Chartered Surveyors (RICS) and the International Facility Management Association (IFMA).

Sakar, A. (2021). Inportance of IoT in Facility Management. *International Journal of Recent Scientific Research, 12*(6), 41870 - 41876. doi: 10.24327/ijrsr.2021.1206.xx

Sampaio, R. P., Costa, A. A., and Flores-Colen, I. (2022). A Systematic Review of Artificial Intelligence Applied to Facility Management in the Building Information Modeling Context and Future Research Directions. *Buildings, 11*(1939). doi: 10.3390/buildings12111939

Samson, R., Navale, G. R., and Dharne, M. S. (2020). Biosensors: frontiers in rapid detection of COVID-19. *3 Biotech, 10*(9), 385. doi: 10.1007/s13205-020-02369-0

Saylan, Y., Erdem, Ö., Ünal, S., and Denizli, A. (2019). An alternative medical diagnosis method: biosensors for virus detection. *Biosensors, 9*(2), 65. doi: 10.3390/bios9020065

Singh, R., Mukherjee, M. D., Sumana, G., Gupta, R. K., Sood, S., and Malhotra, B. D. (2014). Biosensors for pathogen detection: A smart approach towards clinical diagnosis. *Sensors and Actuators B: Chemical, 197*, 385-404. doi: 10.1016/j.snb.2014.03.005

Smith, R. L. (2000). Sensors. In R. C. Dorf (Ed.), *The Electrical Engineering Handbook* Boca Raton: CRC Press LLC.

Souf, S. (2016). Recent advances in diagnostic testing for viral infections. *Biosci Horizons Int J Student Res., 9*. doi: 10.1093/BIOHORIZON S/HZW010

Springer, T. (2004). Facility Management - An Introduction. In E. Teicholz (Ed.), *Facility Design and Management Handbook.* (pp. 5 - 30). New Jersey: McGraw Hill.

Stillings, N. A., Weisler, S. E., Chase, C. H., Feinstein, M. H., Garfield, J. L., and Rissland, E. L. (1995). *Cognitive Science: An Introduction* (2nd ed.). Cambridge, MA: The MIT Press.

Tanpipat, W., Lim, H. W., and Deng, X. (2021). Implementing Remote Working Policy in Corporate Offices in Thailand: Strategic Facility Management Perspective. *Sustainability, 13*(3). doi: 10.3390/su13031284

Tanrıvermiş, H. (2020). Possible impacts of COVID-19 outbreak on real estate sector and possible changes to adopt: A situation analysis and general assessment on Turkish perspective. *Journal of Urban Management, 9*(3), 263-269. doi: 10.1016/j.jum.2020.08.005

Teicholz, E. (2004). *Facility Design and Management Handbook*. New York: McGraw-Hill.

Teja, R. (2021). What is a Sensor? Different Types of Sensors and their Applications. Retrieved 27th December, 2022, from https://www.electronicshub.org/different-types-sensors/

Tuomela, A., and Phuto, J. (2001). Service provision trends of facilities management in Northern Europe: Department of Construction Economics and Management, Helsinki University of Technology.

Villagrasa, J. P., Colomer-Farrarons, J., and Miribel, P. L. (2013). Bioelectronics for Amperometric Biosensors. In T. Rinken (Ed.), *State of the Art in Biosensors* (pp. 241 - 274). London: Intech.

Xie, X., Lu, Q., Herrera, M., Yu, Q., Parlikad, A. K., and Schooling, J. M. (2021). Does historical data still count? Exploring the applicability of smart building applications in the post-pandemic period. *Sustainable Cities and Society, 69*, 102804. doi: 10.1016/j.scs.2021.102804

Zhou, L., Chandrasekaran, A. R., Punnoose, J. A., Bonenfant, G., Charles, S., Levchenko, O., Badu, P., Cavaliere, C., Pager, C. T., and Halvorsen, K. (2020). Programmable low-cost DNA-based platform for viral RNA detection. *Science Advances, 6*(39), eabc6246. doi: 10.1126/sciadv.abc6246

An Assessment of the Effect of Coastal Externalities on Residential Housing Prices in Badore, Lagos-Nigeria

Ayoola, A. B.[1] & Akande S. O.[2]
[1] Department of Estate Management & Valuation, Federal University of Technology, Minna, Nigeria.
[2] Department of Urban and Regional Planning, Federal University of Technology, Minna, Nigeria.
Corresponding author: ayobabatunde@futminna.edu.ng (2347038354214)

Abstract

The paper employed hedonic price model in the estimation of the effect of coastal externalities on the rental value of residential property in Badore community of Lagos, Nigeria. Previous investigations on coastal community property values particularly in the developed economies have revealed that, proximate residential property to coastline areas have presented a worthwhile value to investors across the globe with those residential properties fronting the coastline outperforming those with reasonable distance from the coastline zones. Intrigued by this finding, the current study therefore undertook its investigations from two dimensional perspectives which are to determine if a similar result exists for Badore community, a coastal area in Ibeju-Lekki local municipality of Lagos State. Data was collected from 256 structured questionnaires completed by household heads who are tenants within 500 meters of the coastline in the study area. Model 1A-C accounted for the influence of coastal amenities and other housing attributes on rent. Model 2A-C accounted for the effect of the interaction between coastal amenities/disamenities alongside other housing attributes on rent. The results suggest that for a mean-priced home (N224,846) at the mean distance from the coastline (282.96 m), a 1% increase in distance from the coastline would result in a 0.04%or N34.17 increase in rental value. When disamenity was controlled for in the entire- sample hedonic model, flooding further lower house rents in Badore by 0.12% (N94.56) for every 1% decreasing distance to the coastline.

***Keywords**: Coastal Externalities, Housing Attributes, Hedonic Modelling, Houses, Rent.*

1.0 Introduction

Globally, there are several reasons why people may desire to locate near the coast. In other words, the coastal area offers both physical and intangible benefits to households. These benefits include coastal view, cleaner air, cooler ambient temperatures, recreational resource, provision of job, means of transportation and tourism (Conroy and Milosch, 2011; Parker and Oates, 2016).

Simultaneously, there are disadvantages associated with living near the coast (Voice et al., 2006; Conroy and Milosch, 2011; Goussard, and Ducrocq, 2014). The drawbacks involve increased number of cloudy days, higher population densities, historically higher traffic congestion, storm and ocean surges (Conroy and Milosch, 2011; Adelekan, 2013). Despite the supposed hitches associated with coastal areas across the globe, it has been established that coastal shorelines are desirable locations by people to live in, Lagos coastal areas not an exception (Dada, 2009; Daniel et al., 2009; Below et al., 2015; Campbel, 2015). Furthermore, other earlier studies such as Bin and Kruse (2006) and Bin et al. (2009) have revealed that property values in coastal areas have been beneficial to investors across the world with the proximate properties to coastline performing better than those at rows behind as distance to the coastline increases.

The current study therefore assesses the effect of coastal externalities on residence from being located near the coastline while controlling for other important housing attributes in Badore Community, Lagos State. The remaining sections of this paper are organized as follows: section 2 reviews the literature concerning the effect of coastal externalities on property values. The study area and data are described in sections 3 and 4 respectively. The Methodology is explained in section 5. The empirical results are presented in Section 6. Finally, section 7 draws some conclusions from the analysis.

2.0 Literature Review

Coastal housing and property value modelling studies is a large field. The trend of discourse in the field in recent time has been devoted to the study and evaluation of the effect of coastal amenities and disamenities on property values. Bourassa et al. (2004) used 4,814 sales transactions to gauge the relative effects of 4 aesthetic externalities on property values in Auckland, New Zealand. The aesthetic externalities include several dimensions of view, appearance of landscapping in the neighbourhood, appearance of structures in the neighbourhood and appearance of immediately surrounding improvements. The authors found a hierarchy of impact with wide views of water earning the highest premium of 59% compared to average quality of the houses in the neighbourhood that commanded on average price premium of 37% and the average quality of the properties immediately surrounding the property in question earning premium of 27%. They found that poor-quality landscapping on average lowers property values by 51% while superior landscapping, though insignificant raises house price by approximately 10%. The authors concluded that aesthetic externalities are multidimensional and can have a substantial impact on residential property values.

In Victoria Garden City (VGC), Lagos, Udechukwu and Johnson (2010) utilized hedonic price model and t-test to compare the values of homes with and without lagoon view. They examined sales data from 83 occupiers of residential properties on disproportional basis, with 32 of the occupiers in lagoon view zone and remaining 51 occupiers in non-lagoon view zone. The t-test revealed that view adds significantly to the value of residential properties. The hedonic regression also confirmed the t-test result. The authors after controlling for the relevant determinants of property values concluded that home with a view commands a premium of 8% or N2.59 million naira more than homes without a view. Similarly, Makinde and Tokunboh (2013) employed hedonic pricing model to examine the impact of water view on sales transaction between February 2005 and March 2011 in VGC, Lagos, Nigeria and found that full view on average property increased the housing price by 47.9% when simultaneously controlled with other significant house price determinants.

Gordon et al. (2013) concentrated on condominium sales to account for externalities associated with their location. They used hedonic pricing model to analyse 1,051 sales along the Gulf Coast (Gulf Shores, Orange Beach, and Fort Morgan) of Alabama from 2006 to early 2011. They noted that positive externalities such as better views, increased privacy and noise reduction are associated with higher floor locations and capitalized into property values. Their hedonic model estimated that units on higher floors earned price premium of over 12% than ground level units while corner units sell at a premium of 3% over interior units.

Each of the studies (Bourassa et al., 2004; Udechukwu and Johnson, 2010; Makinde and Tokunboh, 2013; Gordon et al., 2013) that examined property value effect of water view has used generic definition of view (that is 'view' or 'no view') to measure amenities associated with coastline. Also, the studies did not account for the disamenities associated with the coastline. In this study, whilst controlling for coastal disamenity, the Euclidian linear distance from individual residential property to the nearest coastline was used which is an improvement over past studies that rely on the generic definition of view.

Posey and Rogers (2010) investigated 69,022 home sales prices in St. Louis County, Missouri. Their spatial hedonic model revealed a sales price discount of 8.6% for a home in special flood hazard areas (SFHA) compared to a home in non-special flood hazard areas (NSFHA). Their empirical study did not attempt to account for amenities associated with the rivers.

McKenzie and Levendis (2010) used hedonic price analysis to examine 9,001 homes sold 20 months prior to Hurricane Katrina of August 29, 2005 and 18 months after in greater New Orleans. Prior to Katrina, the authors found that waterfront properties in flood-prone areas commanded a premium of 14.3% while in areas not flooded, although not significant, waterfront properties commanded a premium of approximately 8%. They found that after Katrina, waterfront properties in flood prone areas commanded a premium of approximately 32% but a 24.1% premium if the property was not flooded. The authors concluded that houses that were flooded in Katrina displayed a lower sensitivity to future flood risk.

Yi and Choi (2020) examined the effect of actual inundation of the 2008 flood on single family detached residential properties sold between 2000 and 2012 for each level of flood risk area in Iowa, United States. The authors found that before the flood, property prices in 100-year floodplains without inundation declined by 20.4% indicating the reflection of flood risk in property values, but after the flood, there is no significant effect if floodplains were inundated while the prices of properties significantly increase by 28.4% if floodplains were not inundated during the flood. They found that in 500-year floodplains, the prices of properties before the flood, although insignificant declined by 6.7%, but after the flood, the prices of properties significantly decrease by 67.9% if floodplains were inundated while the prices of properties insignificantly declined by 4% if floodplains were not inundated during the flood. Their findings also revealed that house prices in non-floodplain areas decline by 4.8% if floodplains were inundated. The authors concluded that the inundation in non-floodplain areas and in 500-year floodplains is new information to the housing market, and the results can be interpreted as the market response to the updated flood risk.

The previous studies of McKenzie and Levendis (2010) and Yi and Choi (2020) have used floodplain locations as proxy for flooding to account for coastal disamenities. Daniel et al. (2009) declared that a floodplain location specifying dummy variable may misjudge the value of risk of flooding as existence of water is related to both negative and positive spatial amenities. Therefore, in this study, flood occurrence rate was used to account for coastal disamenities over the studies that rely on historical floodplain maps to account for coastal disamenities.

3.0 Study Area

Lagos State is a State in South-western part of Nigeria, bordering Ogun State in the North and East. Its Western border is defined by the Republic of Benin and in the South, it stretches for 180 kilometres along the coast of the Atlantic Ocean. Lagos State lies on Latitude 6˚27΄11˝N and Longitude 3˚23΄45˝E (Oteri and Ayeni, 2016).

Badore community is a growing settlement in Ibeju-Lekki local government area. Ibeju-Lekki LGA is bounded in the west and east by Eti-Osa and Epe local government areas while its southern end is defined by the Atlantic Ocean. The local government area is about 75 kilometres long and 20 kilometres at its widest point covering land and water areas of 643 km^2 and 10 km^2 respectively (Omenai and Ayodele, 2014; LBS, 2015). Figure 1 shows the map of the study area.

The area covered in this study with a cut-off of 500m to the coastline spans along the coastline covering Badore axis from Okun-Ajah, Badore to Okun-Mopo Akinlade/Mopo Alayo through to Okun-Mopo Ijebu Lekki. Okun-Ajah, Badore area of the axis is the most developed in terms of real estate market. The study area is home to many tribes but the Yorubas' are the populous. The area covered in this study with a cut-off of 500m to the coastline and stretch of 5.57 kilometres along the coastline, spanning from Prime beach through several other beaches to Redline leisure & resort down to Okun-Mapo, Ibeju Lekki.

4.0 Data

The residential property types vary across the communities on Badore axis. The predominant residential property types found and used for this study include tenement, two- and three-bedroom blocks of flats and bungalow. Taking a cue from Gopalakrishnan et al. (2009), the residential properties within 500m of the coastline was counted and the figure stands at 1,067. After ground-truthing, the physically identified rented residential properties within 500m of the coastline in the study area amounted to 284, which constituted the sample for the study. After data cleaning, 256 questionnaires were validly completed from the 284 tenants (Table 1). Out of the observations, 35.94% are within 250m of the coastline, while the remaining 64.06% are located between 251 and 500 m of the coastline.

The data extracted from questionnaire survey of these properties pertain to house rent, structural, locational, neighbourhood and environmental attributes. The data include house rent, building age, floor area, number of bedrooms, number of bathrooms, number of floors and presence of garage.

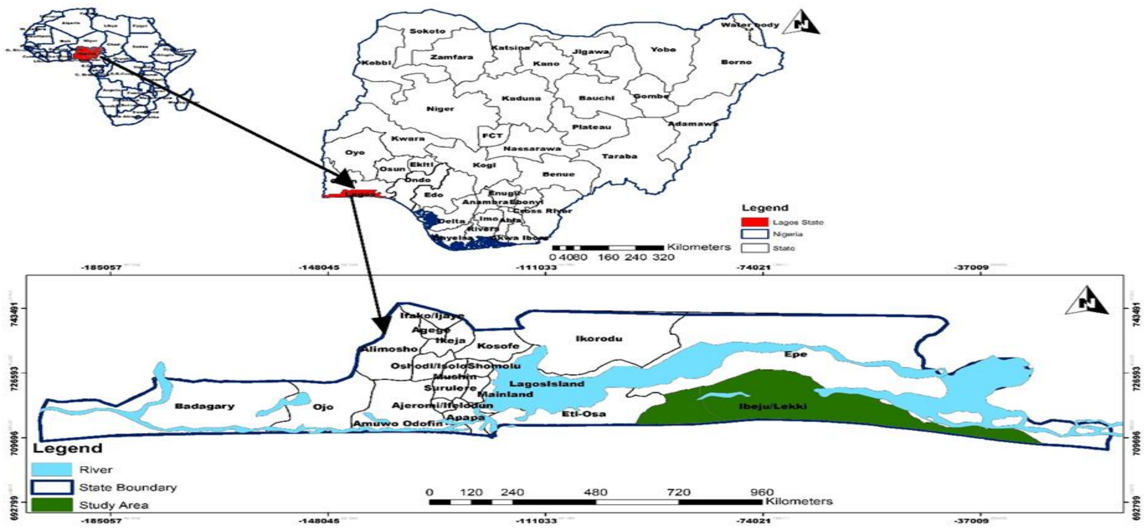


Figure 1: Map of the study area.

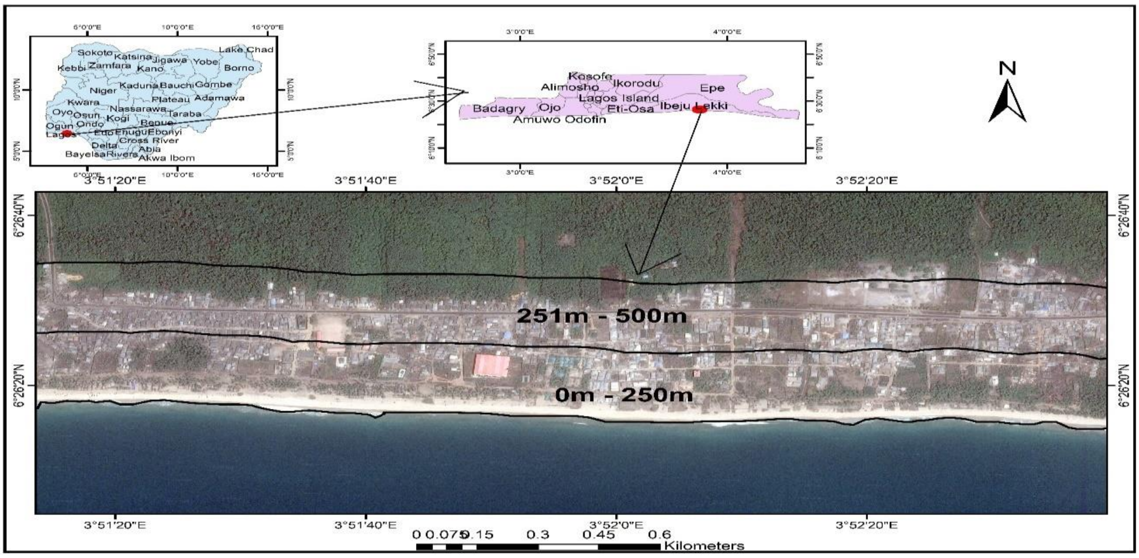


Figure 2: Map of the surveyed area with residential properties at an incremental distance of 250 m to Coastline.

Table 1: Questionnaire Administration

Distance to coastline	*Coastline stretch*	*Questionnaire Administered*	*Retrieved*	*Valid*
Within 250 m	*Residential buildings along Badore*	*102*	*95*	*92*
Between 251 & 500m	*Axis close to the Coastline from prime beach through several others to*	*182*	*170*	*164*
Total	*Redline leisure & resort down to Okun-Mapo, Ibeju Lekki*	*284*	*265*	*256*

Others are condition of building, landscape quality, distance of house to bus stop, distance of house to work place, distance of house to nearest coastline and rate of flood occurrence. Subsequently, the highly correlated variables namely building floor area, number of bedrooms and number of bathrooms are represented by the single variable number of bedrooms to avoid multi-collinearity problems in the hedonic models. The variables used, their definition and descriptive statistics are presented in Table 2.

As displayed in Table 2, the houses in the sample have a mean annual rent of about N 224,846 and the average house is over 13 years of age, with approximate 99 square metre of living space, 2 bedrooms, 2 bathrooms, and on 1 floor. An average property has an average distance of 282.96m from the coastline with rate of flood occurrence averaging 1.41 indicating low level. 14% of the properties have their external walls in excellent condition.

Table 2: Variables used, Definition and Descriptive Statistics

Variables	*Definition*	*Minimum*	*Maximum*	*Mean*	*Std. Dev*
RENT	*Rental price = dependent variable*	*12000*	*946000*	*224846*	*240049*
BLDAGE	*Age of Building*	*2*	*51*	*13.73*	*9.31*
BFLOAREA	*Floor Area of Building*	*30*	*240*	*98.57*	*64.67*
NBEDROOM	*Number of Bedroom*	*1*	*3*	*1.68*	*0.82*
NBATROOM	*Number of Bathroom*	*1*	*4*	*1.84*	*1.12*
NFLOORS	*Number of Floor*	*1*	*4*	*1.25*	*0.48*
GARAGE_YES	*1 if property has a garage, otherwise 0*	*0*	*1*	*0.42*	*0.49*
BLDCOND_Excellent	*1 if the condition of building is rated excellent, otherwise 0*	*0*	*1*	*0.14*	*0.35*
DISTWORK	*Distance to Workplace (in metre)*	*0*	*200000*	*19043*	*31250.82*
DISBSTOP	*Distance to Nearest Public Transport Bus stop (in metre)*	*12*	*2397*	*560.74*	*508.52*
DISTSCH	*Distance to Nearest School (in metre)*	*7*	*1373*	*339.52*	*357.99*
LSCAPQUA_Excellent	*1 if neigbourhood landscape quality is rated excellent, otherwise 0*	*0*	*1*	*0.08*	*0.27*
DISCOAST	*Distance to Nearest Coastline (in metre)*	*25.53*	*497*	*282.96*	*113.54*
FLODRATE	*Rate of flood occurrence in the last two years**	*1*	*3*	*1.41*	*0.78*

**An index was derived for measurement of flood rate and ranked as: 1=low (between 0-2 times) 2=medium (between 3-4 times) 3=high (more than 4 times)*

5.0 Methodology

The hedonic price models, estimated with the log-log functional form was used to analyse the data. The hedonic model takes the rental value of residential properties as the dependent variable, which is on ratio scale while the independent variables constitute housing attributes which are either on ratio scale or dichotomous dummy variable or interval scale. The log-log specifications for the hedonic price models bearing in mind model based on estimation of coastal amenity as captured by distance to the coastline and model based on the interaction of the coastal amenity with the flood occurrence are as shown in equations (1) and (2):

$$LogRENT = ß_0 + ß_1 logBLDAGE + ß_2 logBFLOAREA + ß_3 logDISTWORK + ß_4 logDISBSTOP + ß_5 logDISTSCH + ß_6 logDISCOAST + ß_7 NBEDROOM + ß_8 NBATROOM + ß_9 NFLOORS + ß_{10} GARAGE\_Yes + ß_{11} BLDCOND\_Excellent + ß_{12} LSCAPQUA\_Excellent + \varepsilon \quad (1)$$

$$LogRENT = ß_0 + ß_1 logBLDAGE + ß_2 logBFLOAREA + ß_3 logDISTWORK + ß_4 logDISBSTOP + ß_5 logDISTSCH + ß_6 log(DISCOAST*FLODRATE) + ß_7 NBEDROOM + ß_8 NBATROOM + ß_9 NFLOORS + ß_{10} GARAGE\_Yes + ß_{11} BLDCOND\_Excellent + ß_{12} LSCAPQUA\_Excellent + \varepsilon \quad (2)$$

Where rent is expressed in its natural logarithm, β_0 is a constant term, the coefficients $ß_1$ - $ß_6$ are the percentage change in rent resulting from a percentage change in age, building floor area, house-workplace distance, house-bus stop distance, house-school distance and house-nearest coastline distance (or interaction of distance to coastline and flood occurrence) respectively. The coefficients $ß_7$-$ß_{13}$ reveal the percentage change in rent of having additional bedroom, bathroom, floor and garage as well as for having building condition and neighbourhood landscape in excellent condition. The uncorrelated residual term is ε.

6.0 Empirical Results

The results of the hedonic models are presented in Table 3 and 4. The performances of the overall models for Badore are statistically robust with R-squared statistics ranging from 0.86 to 0.92. The models explain between 86% and 92% of the variance of rents in the study area. Following Field (2009) and Glen (2016), the Durbin-Watson statistics ranging from 1.748 to 1.985 for all the regression models which are close to 2.00 signify that there are no spatial correlations in the residuals of the estimated hedonic models.

The results reveal that of all the physical characteristic variables, number of bedrooms (NBEDROOM) is the most significant determinant of rental values. Across the models, number of bedrooms has positive coefficient and significant at the 0.1% level. The coefficient on NBEDROOM is large across all the 6 models, suggesting that an additional bedroom contributes a premium of between 68% and 76% to house rents. The coefficient estimates on the structural attribute for garage (GARAGE_YES) in models (1A), (1C), (2A) and (2C) is positive and significant but insignificant in model (2B). The results suggest that garage increases rental price by approximately 10% for properties up to 500 metres of the coastline while the attribute adds approximately 16% to the house rent in properties between 251 and 500 metres away from the coastline.

Regarding the location variables across the models, proximity to workplace and public transport bus stop increases house rent, whereas proximity to a school has a negative *influence. As the results show, decreasing the distance from home to workplace (LogDISTWORK) by 1% adds from 0.04% to 0.06% to the rental price. Similarly, decreasing the distance from home to public transport bus stop (LogDISBSTOP) by 1% increases house rent in a range of from 0.09% to 0.13%. In contrast, decreasing the distance from home to a school (LogDISTSCH) by 1% results in a decrease in house rent across the models by approximately 0.2%.*

*Moving on to the variable of interest, the coefficient for Log of distance to Coastline (LogDISCOAST) is positive but insignificant for model (1A). As the result show, a 1% increase in distance from the coastline leads to rise in property values by 0.04% which is equivalent to N34.17 when evaluated at the average house rent among homes up to 500 metres of the coastline. The result implies that distance to coastline has a weak effect on the rent of the properties with increasing returns. The coefficient on Log(DISCOAST*FLODRATE) in model (2A) indicates that when flooding becomes an issue, increasing the distance to the coastline by 1%, there is significant discount of about 0.12% associated with properties up to 500 metres of the coastline, equivalent to N94.56 when evaluated at the average house price. The result implies that when flooding is accounted for, proximity to the coastline is not desirable and increasing distance from the coastline has a strong positive impact on the property rents.*

Turning to the segmented models, without controlling for flood occurrence, among homes within 250 metres of the coastline (model 1B), the variable LogDISCOAST is negative but insignificant. The result implies that proximity to the coastline is fairly desirable and increasing distance from the coastline has weak negative effect on the house rent. As the result shows, a 1% increase in distance from the coastline is associated with a 0.004% or N3.47 decline in property rent. When flood occurrence is accounted for within 250 metres of the coastline, the sign and magnitude of the coefficient on Log(DISCOAST*FLODRATE) in model (2B) suggests that proximity to the coastline is not desirable and increasing distance from the coastline has weak positive effect on the house rents. To state this in a more concrete way, for every 1% increase in distance from the coastline, flooding increases house rent by N84.91 (0.098%).

The weak negative impact of the increasing distance from the coastline on the house rents in model 1B fizzles out in location between 251 and 500 metres away from the coastline (model 1C). Hence, in model (1C), increasing distance from the coastline results in a weak positive effect on the house rents. The result suggests that the location between 251 and 500 metres away from the coastline increases the house rent by 0.08% (N60.54) evaluated at the mean property value for every 1% increase in distance from the coastline. When flood occurrence becomes an issue in model (2C), increasing distance from the coastline results in a strong positive effect on the house rent. As the result shows, in location between 251 and 500 metres away from the coastline, flooding increases house rent significantly by 0.23% (N179.29) for every 1% increase in distance from the coastline.

7.0 Conclusion

The results presented in this paper suggest that proximity to coastline has weak negative effect on rent for properties within 500 metres of the coastline, though exert weak positive effect on rent for properties within 250 metres of the coastline. When coastal disamenities are controlled for, proximity to coastline has a strong negative effect on rent for properties within 500 metres of the coastline and by extension impact on house price. Generally, flooding, which constitute negative externality dampen rent by 0.12% (N94.56) within the study area. The result further signifies that house rents tend to increase with increasing distance from the coastline. The study recommends that coastal managers should adopt sound protection measures of the coastline in the study area. With this recommendation, it is hoped that the reflection of flood risk observed in house rents fronting the coastline will decline while rental values are likely to perform better. However, the result of this study is consistent with evidence provided in the psychology literature on general human behaviour (Below et al. 2015).

Table 3: Log-log Hedonic Price Models of Coastline and Housing Characteristics for Badore (Non-Flood Effect)

	Model 1A(0-500m)		Model 1B(0-250m)		Model 1C(251-500m)	
VARIABLES	Coefficient	t-Statistic	Coefficient	t-Statistic	Coefficient	t-Statistic
Constant	3.953	18.184	4.037	8.265	3.856	8.906
LogBLDAGE	0.076	1.520	0.017	0.171	0.108	1.786
NBEDROOM	***0.540	26.929	***0.567	11.670	***0.521	23.146
NFLOORS	0.052	1.956	0.057	0.576	0.051	1.922
GARAGE_YES	**0.091	2.877	-0.009	-0.146	***0.147	3.778
BLDCOND_Excellent	0.029	0.708	0.039	0.358	0.016	0.362
LSCAPQUA_Excellent	0.001	0.012	0.032	0.299	-0.005	-0.083
LogDISCOAST	0.043	0.764	-0.004	-0.032	0.078	0.520
LogDISTWORK	***-0.063	-3.544	-0.046	-1.089	**-0.062	-3.135
LogDISBSTOP	***-0.129	-3.721	-0.116	-1.460	**-0.132	-3.456
LogDISTSCH	***0.199	5.946	**0.184	3.412	***0.196	4.246
R^2	**0.908**		**0.861**		**0.921**	
Adjusted R^2	**0.904**		**0.843**		**0.915**	
Standard Error (SE)	**0.171**		**0.198**		**0.157**	
Durbin-Watson	**1.854**		**1.985**		**1.781**	
F-Statistic	**238.094**		**47.799**		**177.235**	
p-Value	**0.000**		**0.000**		**0.000**	
Observations	**256**		**92**		**164**	

Dependent variable: LogRENT
**** indicates significance at the 0.1% (p<0.001) level*
*** indicates significance at the 1% (p<0.01) level*
** Indicates significance at the 5% (p<0.05) level*

Table 4: Log-log Hedonic Price Models of Coastline and Housing Characteristics for Badore (Flood Effect)

	Model 2A(0-500m)		Model 2B(0-250m)		Model 2C(251-500m)	
VARIABLES	Coefficient	t-Statistic	Coefficient	t-Statistic	Coefficient	t-Statistic
Constant	3.782	19.520	3.751	8.415	3.545	13.496
LogBLDAGE	0.059	1.198	0.023	0.243	0.055	0.894
NBEDROOM	***0.534	26.733	***0.562	11.613	***0.514	23.234
NFLOORS	0.051	1.914	0.050	0.512	0.051	1.955
GARAGE_YES	**0.091	2.946	0.001	0.023	***0.144	3.828
BLDCOND_Excellent	0.002	0.037	-0.006	-0.047	-0.025	-0.546
LSCAPQUA_Excellent	-0.018	-0.371	0.023	0.217	-0.036	-0.652

*Log(DISCOAST*FLODRATE)*	**0.119*	*2.481*	*0.098*	*0.893*	**0.231*	*2.744*
LogDISTWORK	***-0.061*	*-3.481*	*-0.040*	*-0.960*	***-0.061*	*-3.169*
LogDISBSTOP	***-0.107*	*-3.119*	*-0.090*	*-1.138*	***-0.114*	*-3.056*
LogDISTSCH	****0.178*	*5.278*	***0.173*	*3.223*	****0.165*	*3.539*
R^2	***0.910***		***0.863***		***0.924***	
Adjusted R^2	***0.906***		***0.845***		***0.919***	
Standard Error (SE)	***0.169***		***0.197***		***0.154***	
Durbin-Watson	***1.819***		***1.942***		***1.748***	
F-Statistic	***244.138***		***48.374***		***186.354***	
p-Value	***0.000***		***0.000***		***0.000***	
Observations	***256***		***92***		***164***	

Dependent variable: LogRENT
**** indicates significance at the 0.1% (p<0.001) level*
*** indicates significance at the 1% (p<0.01) level*
** indicates significance at the 5% (p<0.05) level*

References

Adelekan, I. (2013). Private sector investment decisions in building and construction: Increasing, managing and transferring risks: Case study of Lagos, Nigeria. Background Paper Prepared for the Global Assessment Report on Disaster Risk Reduction, Geneva, Switzerland.

Below, S., Beracha, E. and Skiba, H. (2015). Land erosion and coastal home values. Journal of Real Estate Research, 37(4), 499-535.

Bin, O. and Kruse, J.B. (2006). Real estate market response to coastal flood hazards. Natural Hazards Review, 7(4). Retrieved from https//ascelibrary.org

Bin, O., Poulter, B., Dumas, C.F. and Whitehead, J.C. (2009). Spatial hedonic models for measuring the impact of sea-level rise on coastal real estate. Retrieved from www.researchgate.net

Bourassa, S.C., Hoesli, M., and Sun, J. (2004). What's in a view? Environment and Planning A, 36, 1427-1450.

Campbell, E. (2015). Some like it hot: The impact of climate change on housing markets. The Student Economic Review, 29, 97-106.

Conroy, S.J. and Milosch, J.L. (2011). An estimation of the coastal premium for residential housing prices in San Diego County. J Real Estate Finan Econ, 42, 211–228.

Dada, A. (2009, December 28). Eko atlantic city: Daring the waves. Punch Newspaper. Retrieved from http://www.ekoatlantic.com/category/latestnews/press-clipping/

Daniel, V.E., Florax, R.J.G.M. and Rietveld, P. (2009). Floods and residential property values: A hedonic price analysis for the Netherlands. Built Environment, 35(4), 563-576.

Gordon, B.L., Winkler, D., Barrett, J.D., & Zumpano, L. (2013). The effect of elevation and corner location on oceanfront condominium value. Journal of Real Estate Research, 35(3).

Goussard, J.J. and Ducrocq, M. (2014). West African coastal area: Challenges and outlook. In S. Diop et al. (Ed.), The land/ocean interactions in the coastal zone of west and central Africa, estuaries of the World. Switzerland: Springer International Publishing.

Makinde, O.I. and Tokunboh, O.O. (2013, October 23-26). Impact of water view on residential properties house pricing. Paper presented at the American Real Estate Society Conference, Kigali, Rwanda.

McKenzie, R. and Levendis, J. (2010). Flood hazards and urban housing markets: The effects of Katrina on New Orleans. J Real Estate Finance Econ, 40, 62–76.

Omenai, J. and Ayodele, D. (2014). The vulnerability of Eti-Osa and Ibeju-Lekki coastal communities in Lagos State Nigeria to climate change hazards. Research on Humanities and Social Sciences, 4(27), 132-142.

Oteri, A.U and Ayeni, R.A. (2016). The Lagos Megacity – Introduction and Water Resources. In: Water, Megacities and Global Change. Retrieved from www.eaumega.org on the 3rd March, 2017.

Parker, H. and Oates, N. (2016). How do healthy rivers benefit society? A review of the evidence. Retrieved from http://www.odi.org

Posey, J. and Rogers, W.H. (2010). The impact of special flood hazard area designation on residential property values. Public Works Management & Policy 15(2), 81-90.

Udechukwu, C.E. and Johnson, O.O. (2010). The impact of lagoon water views on residential property values in Nigeria. The Lagos Journal of Environmental Studies, 7(2), 21-26.

Voice, M., Harvey, N. and Walsh, K. (Eds). (2006). Vulnerability to climate change of Australia's coastal zone: Analysis of gaps in methods, data and system thresholds. Retrieved from www.eprints3.cipd.esrc.unimelb.edu.au

Commercial Property Market Performance and Macroeconomic Indicators Amid COVID-19 in Lagos: The Causal Linkage

Wahab, M.B.[1], Alalade, O.[2] & Hassan, O.A.[3]
[1]Estate Management Department Kaduna State University, Kaduna State
[2]Estate Management Department, Kaduna Polytechnics
[2]Estate Management Department Kwara State Polytechnics, Ilorin
babatunde.wahab@kasu.edu.ng

Abstract

The study investigated linkage between real estate office market performance and covid-19 driven macroeconomic indicators in Nigeria. Many related previous studies are valuable in the field of macroeconomic dynamics in real estate markets, but a vacuum still exist due recent development in the economy caused by covid-19 pandemic and subsequent impact on commercial property investment in Lagos. Monthly returns on commercial real estate investment (office) from sampled registered real estate firms in addition to data on macroeconomic indicators were obtained for the period (February, 2020 and December, 2021). These data were then analysed using econometric analysis - Augmented Dicker Fuller (ADF), Granger causality test and Engle Granger cointegration. The result pairwise correlation between covid-19 rate of infection and macroeconomic variables revealed that significant change in rateof covid-19 caused significant change in macroeconomic variables. The empirical evidence shows a long run negative impact of covid-19 driven macroeconomic indicators on real estate market. The study further understood that correction in market disequilibrium caused by economic disruption would require a slow adjustment. The real estate investor should exercise caution in investing into real estate due market disruption or disequilibrium that would take long period to correct. This paper provides empirical evidence of interrelationship between covid-19 driven macro economy and office commercial markets. The result further revealed a spill-over effect of covid-19 in the economy in real estate office market and this spill-over effect is yet to be fully manifested and therefore government intervention to correct future abnormalities in the real estate market is highly recommended.

Keywords: office returns, macroeconomic indicators, commercial property market.

Introduction

Commercial Property market and the economy had been found to be interdependent, such that both impact on each other, such that, falling interest rate in economy results to lower cost of economic capital development and hence encourages property market investment; as such an increase in investment in turn results to economic upturn i.e increase in productivity (Apergi 2003; Ge, 2009; Ojetunde, 2013; Wahab *et al.*, 2017; Wahab *et al.*, 2018). Therefore, the fluctuated nature of macroeconomic parameters significantly influences the investor decisions and also determine property return, such that whenever property market is affected by fluctuated economic parameters, the resultant effect is either soft or tight property market. In the period of economic stability and growth, soft market experiences excess supply over demand and causes low return to investors and otherwise leads to tight market (Born & Pyhrr 1994). GDP as a measure of overall performance in economic activities, exerts a major influence on investor's decision, such that any positive change in GDP results to positive change in property return and vice versa (Pend &Hudsin-wilson, 2002; Clarke & Daniel, 2006).

Dynamics of commercial property return occurs when macroeconomic factors change, and slow adjustment of return to changes in macroeconomic policy creates a lag time, this generally makes property market to exhibit low price fluctuation. Besides, house rent sluggishness also leads to irrational exuberance bubble or influences in the property market during economic booms. Unexpected changes in macroeconomic factors such as money supply, GDP, interest rate etc affects house return with a lag therefore lead to fluctuation in property investment, depending on the speed of transmission mechanism. The speed of transmission depends on the efficiency and effectiveness of the institutional framework of Nigeria which includes the speed of administrative process, credit supply, and land availability for investment and so on.

Commercial property investment performance in Lagos has been influenced by macroeconomic factors due to backward and forward relationship between the property market and the economy. The aftermath is the rise and fall in property investment return together with unpredictable variation in the future of property investment returns. This has been the major source of contention among real estate investors. Property is an integral part of a country's economy; by implication the economy affects the property market therefore overall performance in property market is dependent on the state of a nation's economy (Fraser 1993; Belo & Agbatekwe 2002). Dynamic operation of macroeconomic indicators in real estate market amid covid-19 formed basic premise of this study, it needs to be investigated. Since convid-19 is global pandemic that affect virtually every sector of countries' economy including real estate sector, studying dynamic effect of macro economy disruption caused by convid-19 in real property market is a focal point of this study. Since real estate sector is linked to national economy, therefore, examining the dynamic changes in covid-19 driven macroeconomic factors on real estate market becomes sacrosanct to every stakeholder's property market in order to understand the future implication. Firstly, the study established causal linkage between rate of covid-19 infections and macro-economic indicators in Nigeria and finally the effect of covid-19 driven macroeconomic factors on real estate market in Nigeria. The study therefore aimed at determining the degree of the interdependent relationship in both short-run and long run between covid-19 driven macroeconomic indicators and returns on office properties with a view to ascertaining the extent of interdependency that exists.

Literature Review

Property Market Sector and Macro Economic Policy Indicators

Property market and macro economy are interlinked and intertwined. They are positively related to each other and they are interrelated in both short and long run and also influence each other. The literature from myriad of authors all over the world has shown the relationship as follows: Belo and Agbatekwe (2002) submitted that the quality and quantities of the country's housing stock is a measure of the country's economic growth and prosperity. Therefore, real estate sector has also become a focal point of government fiscal and monetary policies and used as yardstick for realizing low level inflation, high level of employment, low level of unemployment and balanced economic growth (Apergis, 2003).

Fraser (1993) has related property market as an integral part of nation's economy, therefore there is reverse implication on one another. This indicates there is a reverse linkage between property market and the macro economy, which implies that, whatever affects the property market also affect the economy, vice versa. In the period of economy instability or macroeconomic fluctuation, disequilibrium in the property market is as a result of exogenous factors originated from government structural and deregulations in the country's economy (Dehesh & Pugh, 1998).

Property market cycles is affected by shocks of macroeconomic factors and resulted into either tight or soft market, in that, in the period of economic stability and growth, the property market cycles are expected to exhibit excess supply, vice versa (Born & Pyhrr, 1994). Property market are linked to macro economy, such that macro-economic factors such as GDP, money supply, inflation, interest etc influence the performance of property market, in that, inflation acts as disincentives to real estate purchaser but acts an incentive to real estate investors, because increase in the property price reduces the demand, and increase in level of employment increases inflation and thus property price, therefore macro economy parameters significantly influence the investor decisions and also determine property return (Giussani *et al.*, 1992). Volatility in property investment market is therefore influenced by these macroeconomic factors and has led to fluctuation in property investment return. Property investment cycles are related to the periods of excess demand and excess supply in real estate market, which are described as tight and soft markets respectively within the property market, and they are primarily affected by macroeconomic policy of national, regional and local economy (Born &Pyhrr, 1994; Apergis, 2003; Ojetunde, 2013; Wahab *et al.*, 2017).

Macroeconomic Indicators and Commercial Real Estate Market: The Causal Linkage

Real Gross Domestic Product (Real GDP) and Real Estate Returns

This is a measure of overall performance of economic activities of the country. Real GDP is therefore a measure of real economic growth and changes which directly influences property market performance. An increase in economic growth increases effective demand and at the same time result to rise in property prices and thus increase property return in that the willingness to pay raises the rental price and thus property returns as well, therefore any expected positive change in real GDP result to positive change in property return, vice versa (Peng & Hudsin-wilson, 2002; Clarke & Daniel, 2006; Sinbad, M. & Mhlanga, R. (2013)). Peng and Hudsin-wilson (2002) has described GDP as overall measure of economic performance that has positive direct impact of shocks on property investment performance.

Interest Rate and Real Estate Returns

This is referred to as cost of borrowing or cost of finance. General interest rate in economic has predictive ability of the country economic future output, and the current and future business condition and investment opportunity is reflected by interest rate (Brooks & Tsolacos, 1999; Brooks & Tsolacos, 2001; Sinbad, M. & Mhlanga, 2013). The future performance of real estate sector in term of it income earning capacity has been linked or related to future trends in the country's economy which is reflected by interest rate. The linkage of interest rate to property investment market is on the ground that it has a predictive power over the property asset price movement. There is an inverse linkage or relationship between rate of interest and property market return, since a high interest rate reduces affordability level of an effective demand for housing properties, thereby reduces the price and thus the property return (Roe *et al*., 2004; Clarke & Daniel, 2006). High interest rate hinders household ability borrow thereby reduces house demand for property investment and also lea decrease in price and return to investors.

One of the theoretical frameworks that link property market to interest rate is Gordon Growth Model. The model has constantly applied in housing market to establish the relationship between the property price return and interest rate (Brooks & Tsolacos, 1999). Gordon Growth Model expressed property price return as ratio of rental value to difference between the interest rate and rental growth rate i.e property price return = rental value/(interest rate-rental growth rate). This indicates that decrease in the level of interest rate, leads to greater elasticity in property price return to the change in interest rate, this relationship between the interest rate and property price return is referred to as convex relationship. In other word, the low the interest rates are the bigger the house price and the return.

The outcome of relationship between interest rate and property return from different authors is often contradictory. Some authors submitted that interest rate contained necessary information on the predictability of return while other found no relationship. Brooks and Tsolacos (2001) has identified the reason for these contradictory findings as follows: the result of individual author is been influenced by the method adopted; and, therefore the types of other real estate return series (total return, capital return and income return series, and return on net stock of market influences) adopted for the study. Therefore, either positive or negative relationship should be expected between interest rate and property return.

Inflation Rate and Real Estate Returns

Inflation is the persistent increase in general price level. It is measure of change in current and old consumer prices expressed as percentage. In some literature, inflation is used as proxy for consumer price index. Every property asset is an inflationary hedged and it is thereby contained an inflationary protecting characteristic (Miregi & Obere, 2014). Inflation rate is positively related to property return. Wong *et al.* (2003) property return increases as inflation rises and they are both positively related. But Ling and Naranjo (1997) find evidence of no relationship between property return and inflation. This contradictory finding is as a result different methodology adopted. Umeh and Oluwasore (2015) studied the inflation hedging capacity of residential property investment in Ibadan between 2002 and 2014, employing ordinary least square regression analysis, the result showed that residential investment did not hedge against actual inflation but hedge against expected inflation, therefore the study concludes that investor should concentrate more on geographical area where residential property return is hedged inflation. Dabara (2014) analyzed the inflation hedging performance of residential property investment in Gombe between 2003-2012, ordinary least square regression analysis was employed, the finding showed that inflation-hedging performance of residential investment provide a partial hedge.

The linkage between inflation and property return lies in fact that real property price is highly sensitive to change in economy in real term, property asset provides a refuge to investor when monetary policy changes either positively or negatively. It is thereby a protective devise against significant inflationary risk (Miregi & Obere, 2014; Wahab *et al.*, 2018). In conclusion real estate property has provided a refuge for government economic deregulation and structural reform to achieve objectives of sustainable economic growth and development, because real estate property houses all.

Exchange Rate and Real Estate Returns

The rate at which one unit of currency of a country is exchanged in term of trade to another country's currency as expressed in percentage. The natural linkage between the exchange rate and property return is on ground that an appreciation (or improvement in value) of the currency will surely hinder foreign investors from investing local property market, in other word, depreciation (that is, to make the currency less valuable in term of other) will surely encourage and magnetize foreign investor to local property investment which leads to increase in local property demand and this will eventually rise property price and return (Clarke & Daniel, 2006). Kwangware (2010) the positive shock of exchange rate encourages an increase in demand for property by local investors and raises the return, vice versa. It is thereby expected that the relationship between the property return and exchange rate should be positive.

Unemployment/Employment Rate and Real Estate Returns

Unemployment and employment represent useful indicators to measure general or overall health of the economy (Ge, 2009). Unemployment is a situation whereby a qualified job seeker cannot find an employment. Unemployment rate is a rate at which the number of available job spaces fall short of labour force, in other word it is a measure of percentage of country population currently unemployed. At equilibrium between property market and labour market, assuming a negative shock on demand for labour force which leads to decrease in workers's wages and salaries and this hence leads to rise in unemployment. The linkage between unemployment and property return is premised on the ground an increase in level of unemployment rate reduces disposable income and hence reduces the effective demand for property and thus leads to decrease in property prices and thus property return (Ge, 2009; Brooks, 2002). They therefore submitted that negative relationship should be expected between unemployment and property return.

Employment is simply a situation where a qualified labour force can gainfully engage financially in an occupation. Employment rate is the rate at which qualified labour gainfully absorbed and engaged financially by the economy. Employment rate is an important factor influencing property prices and return (Giussani *et al.*, 1992; Miregi & Obere, 2014). They thereby established the linkage in such that a positive change in employment level increases the ability to purchase because of disposable income to house has changed, thereby increase demand for property and this lead to rise in property prices and return, vice versa. Therefore, positive relationship should be expected between property return and employment.

Money supply rate and Real Estate Returns

Money supply is total money stock available in an economy for circulation at given period of time. It is the monetary policy of used by central bank to control the economy. An expansionary monetary policy in form rise in money supply, decreases interest rate, ceteris paribus, thereby cost of housing services fall and the quantity demanded for housing services increases this therefore leads to increase in the real property prices as well since property services are linked to property unit (Apergis, 2003). In other word an increase in money supply, reduces interest and thereby increase the level of inflation because of too much cash in circulation, rises the property price and property return, *ceteris paribus*. Thereby there is a positive shock between money supply and property price and return (Apergis & Rezitis, 2003).

Mortgage interest rate and Real Estate Returns

The cost of owning houses referred to the mortgage interest rate. Interest on mortgage is the periodic amount made to mortgagee after an initial lump sum. The linkage between property price return and mortgage rate of interest is premised on the ground that the cost of residential housing is the payment of interest on the mortgaged property. It is therefore empirically deduced that whenever the mortgage interest increases, the individual prospective house buyer is prevented from buying thereby result to falling in demand and reduces property price and return (Apergis, 2003). The scholars have submitted that significant of mortgage influence on household expenditure is arguably expected through house price effect in the system characterized by the role collateral houses as important (Boffoe-Bonnie, 1998; Muellbauer & Murphy, 1997; Wei & Morley, 2012). They conclude that there is inverse relationship between mortgage rate and property price and return.

It is therefore evident from the literature that regional, local and national economy indicators dictate the direction and magnitude of aggregate demand in property investment market. Therefore, the extent of this influence and degree of interdependency of these macroeconomic indicators in Nigerian property market and how they affect the return has not been examined adequately because the previous studies in Nigeria on macroeconomic factors and the property market (Ojetunde*et al*., 2011; Ojetunde, 2013; Udoekanem*et al*. 2014; Udoekanemet *al*., 2015) were relatively few as compared to those of other countries.

Methodology

The study employed simple random sampling technique to collect data on commercial office rental values and capital values from 200 registered estate firms in Lagos and from which returns on commercial properties were computed. The study computed monthly returns on commercial office properties from two commercial centers (Ikeja and Surulere) using the formula shown in equation 1. Monthly information from macroeconomic indices were sourced directly from Central Bank of Nigeria and National bureau of Statistics in addition to data on macroeconomic indicators were obtained for the period (February, 2020 and Feb; 2021). These data were then analysed using econometric analysis - Augmented Dicker Fuller (ADF), Engle Granger cointegration and cointegrating regression analysis. The model for commercial real estate returns (R) is described as in the equation 1.

$$R = \frac{p_t - p_{t-1}}{p_{t-1}} \tag{1}$$

R is commercial office returns indices, Pt is commercial office rent at end of period t, Pt-1 is the commercial office rent beginning of period t expressed in percentage. Monthly data on macroeconomic economic variables between February, 2020 and December; 2021were sought directly from both Central Bank of Nigeria (CBN) annual Bulletin and National Bureau of Statistics (NBS).

VAR model: Vector autoregression is a system in which each variable is expressed as a function of own lags as well as lags of each of the other variables. A VAR is an n-equation, n-variable model in which each variable is in turn explained by its own lagged values, plus (current) and past values of the remaining n -1 variables. Therefore, stationarity test and Granger causality test are properties of VAR.

Stationarity Test: Econometric data is a time series based and they usually non-stationary. The test of stationarity of the series was carried out for the study in order to detect the presence of unit root (non-stationary) or not, and to determining the order of integration of the variables in the model. Augmented Dicker fuller (ADF) test was employed for the study to test for unit roots. The time series properties or variables included in the model were examined using Augmented Dicker Fuller as expressed as follows:

$$\Delta Y_t = \beta_0 + \beta_1 Y_{t-1} + \sum_{i=1}^{k} \mathrm{\pi_i \Delta Y_{t-1}} + \mathrm{U_t} \tag{2}$$

Where Y_t represents vector of time series, t represent time, U_t represents the error terms and π represents the coefficient matrix of the variables, Δ represents differences in variables.

Granger Causality Test: this is a test of causal linkage among the variables. Granger causality is employed to determine causal linkage or relationship between the variables included in the model. The test was adopted to examine the null hypothesis that the movement of macroeconomic variables does not cause immediate change in property market price over a period of time.

Granger Causality test postulates that if y_2 has any influence on y_1 ($\alpha_{12} \neq 0$), one can say y_2 Granger causes y_1. On the other hand, if y_1 has any influence on y_2 ($\alpha_{21} \neq 0$), one can say y1 Granger causes y_2.

$$y_t = \beta_1 y_{t-1} + \beta_2 y_{t-2} \dots\dots + \beta_n y_{t-n} + U_t \qquad (3)$$

Where Y_t represents vector of time series, t represent time, U_t represents the error terms and β represents the coefficient matrix of the variables.

Results

Figure 1 showed the trend in monthly macroeconomic variables in Nigeria between February 2020 and December 2021. It revealed monthly movement and changes in macroeconomic indicators amid of covid-19 pandemic and these changes was associated to rising cases of covid-19 rate of infections.

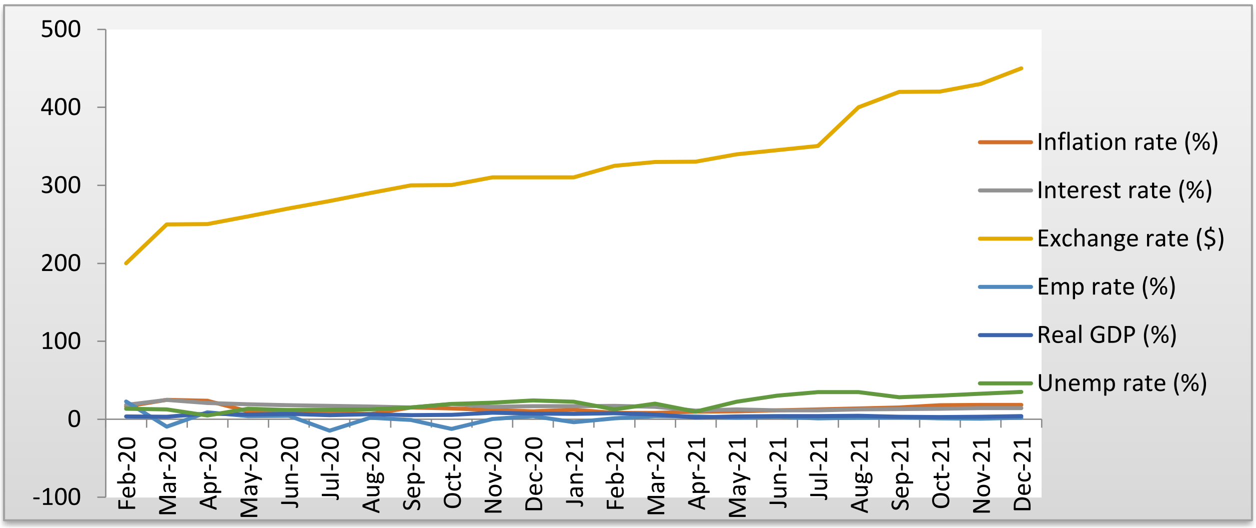


Figure 3:Trend in Macroeconomic Variables in Nigeria

Source: Central Bank of Nigeria (CBN) and National Bureau of Statistics (NBS) (2021)

The Table 1 shows the descriptive statistics of macroeconomic variables over the period of study (Feb 2020- Dec 2021). The average growth rate in Real GDP was 5.83% over the period, and this growth is far behind the growth rate in inflation, interest and unemployment rates which grow at 15.71%, 17.49% and 15.08% respectively.

Table 12: Descriptive Analysis of Macroeconomic Variables in Nigeria

Variables	Mean	Std. Deviation	Minimum	Maximum	N
Real GDP	5.83%	1.72	2.35	8.38	23
Inflation	15.71%	9.46	6.60	24.85	23
Interest Rate	18.49%	3.01	11.02	24.75	23
Exchange Rate	N400.95/$1	21.85	113.46	197	23
Employment	3.52%	9.05	-14.68	22.75	23
Unemployment	12.08%	5.26	4.81	23.92	23

This implies that average economic activities or domestic production has been hindered by increase in inflation, interest and unemployment rates. The growth in Employment rate was 3.52% as compared with unemployment rate at 15.08%, and this suggested that there was wider gap between rate of unemployment and employment whereby employment fell below unemployment rate.

Figure 1 shows the rising cases of COVID-19 pandemic in the study area. the trend revealed that from February 28th 2020 to December 28th 2021, there was slow raising cases covid-19, and after April 28th, there was high rising in number of cases recorded. This was attributed to poor response of government to the pandemic; in term of safety guide and measures against the spread. The sharp raising recorded after April 28th was associated to the fact that the lack preparedness in the case of pandemic. The rising continues till September 19th 2020 and after which there was slow rising in number of cases. This is therefore attributed high of compliance to lock down measures. The gradual reopening from lockdown had suddenly led to sharp rising in number of cases from November 30th till date. The implication is that the global and local economy and financial markets have been severely affected due to the significant reductions in income, a rise in unemployment, and disruptions in the transportation, service, and manufacturing industries caused by the covid-19 pandemic. Consequently, the correction of the damage in the economy required a slow adjustment over a period.

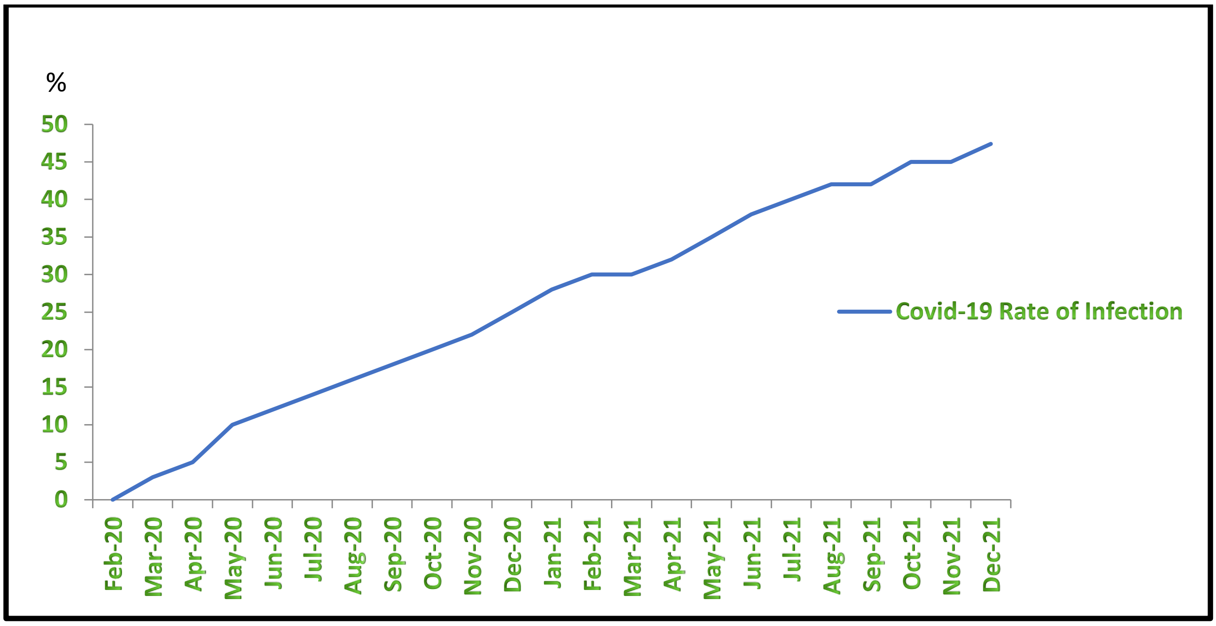


Figure 4 Cumulative Number of Confirmed Coronavirus Cases (COVID-19) in Nigeria from February 28, 2020 to December 20, 2021

Source: Computed from NCDC Monthly Report

The result in Table 2 showed the pairwise correlation between monthly macroeconomics indices and covid-19 rate of infections. The result revealed that there is negative and significant correlation between real GDP and covid-19 rates at -0.628 which indicates an inverse relationship between Real GDP and covid-19 rate of infection. Inflation rate is positively correlated to covid-19 rate of infection. Interest and exchange rates are negatively significant correlation with covid-19. Real GDP and interest rates maintained an inverse relationship with covid-19 rate such that covid-19 causes negative changes in real GDP and Interest rate. Inflation and exchange rates direct relationship such that covid-19 causes positive changes in inflation and exchange rate. Conclusively, covid-19 rate has therefore caused changes in macroeconomic indices in Nigeria. Since real estate sector is linked to national economy, therefore, examining the dynamic changes in covid-19 driven macroeconomic factors on real estate market becomes sacrosanct to every stakeholder's property market in order to understand the future implication.

Table 13: Pairwise Matrix Correlation Between Macroeconomic Variables and Covid-19 rate

		Covid-19 rate	Real GDP	Inflation rate	Interest rate	Exch. rate	Empl. Rate	Unemp. rate
	Pearson Correlation	1						
Covid-19 rate	Sig. (2-tailed)							
	N	23						
	Pearson Correlation	-.628**	1					
Real GDP	Sig. (2-tailed)	.025						
	N	23	23					
	Pearson Correlation	.729**	.020	1				
Inflation rate	Sig. (2-tailed)	.013	.949					
	N	23	23	23				
	Pearson Correlation	.548**	.245	.124	1			
Interest rate	Sig. (2-tailed)	.036	.419	.686				
	N	23	23	23	23			
	Pearson Correlation	.731**	.097	-.085	.242	1		
Exchange rate	Sig. (2-tailed)	.005	.753	.783	.425			
	N	23	23	23	23	23		
	Pearson Correlation	.434	.067	.035	.343	.132	1	
Employment	Sig. (2-tailed)	**.149**	.653	.773	.522	.243		
	N	23	23	23	23	23	23	
	Pearson Correlation	.534	.108	.169	.155	0.339	0.464	1
Unemployment	Sig. (2-tailed)	**.039**	.725	.5613	.596	0.235	0.110	
	N	23	23	23	23	23	23	23

**. Correlation is significant at the 0.01 level (2-tailed).

Figure 2 showed the trend in returns on office properties in Lagos. The returns showed a fluctuated decrease from march 2020 upon the shutdown in the economic activities up till December 2020. The returns witnessed a rise due general re-opening of the economy.

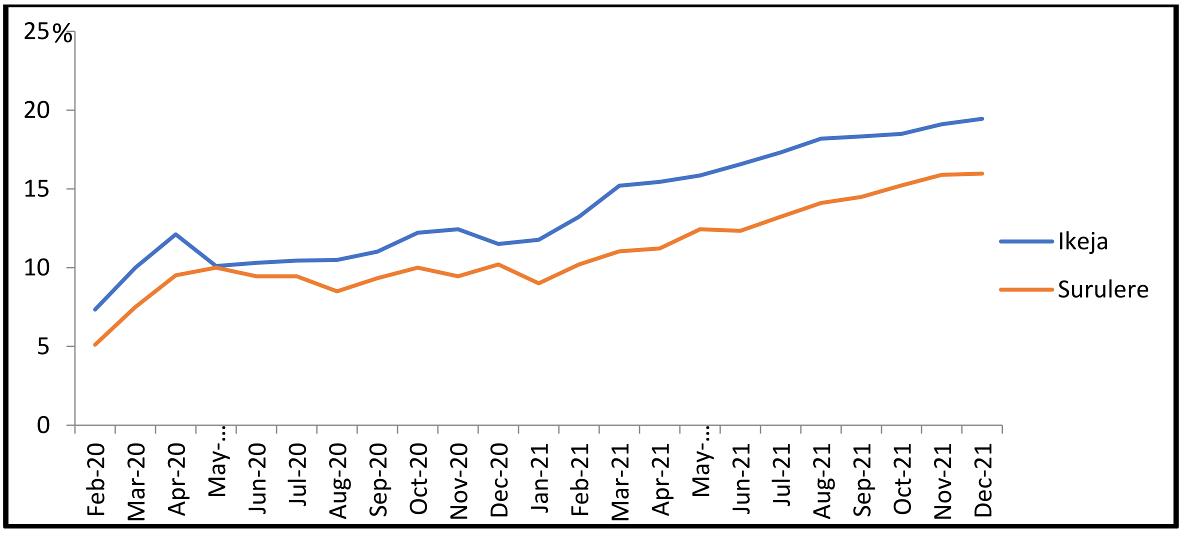


Figure 5: Returns on Office Properties in Ikeja and Surulere

Table 3 shows the result of unit root test carried out through Augmented Dicker Fuller (ADF) on all the variables employed for the study. The result of ADF unit root test showed that real GDP, inflation rate, interest rate, employment rate and unemployment rate are stationary at first-order difference, only exchange rate is stationary at second-order difference, and while property returns from different markets are stationary at level. The implication of this test is that the time series data employed for this study is suitable and appropriate for further analysis. Technically, it implies that the time series variables have no unit root.

Table 14: Stationary or Unit Root Test

Variables	Computed t-statistic	ADF Critical @0.05	Prob.*	Order of integration
Δ Real GPD	-5.003512	-3.144920	0.0025	I(1)
Δ Inflation Rate	-4.296966	-3.144920	0.0075	I(1)
Δ Interest Rate	-7.446427	-3.144920	0.0001	I(1)
Δ Unemployment Rate	-4.444466	-3.144920	0.0059	I(1)
ΔΔ Exchange Rate	-3.604032	-3.175352	0.0255	I(2)
ΔEmployment Rate	-6.405753	-3.119910	0.0002	I(1)
Ikeja Office market (ARt)	-3.483968	-3.119910	0.0066	I(0)
Surulere Office Market (ARt)	-3.866170	-3.119910	0.0139	I(0)

The analysis of causal relationship between macroeconomic variables and office returns is presented in table 4. The test examined the short run causal linkage between the dependent variable and independent variables, the result presented in table 4 revealed both the test of statistic (f-stat) and p-value of the statistic (Prob.) The f-statistics is significant if probability value is less than chosen level of significance at 0.05, and therefore null hypothesis is rejected. Only unemployment rate unilaterally granger causes property returns in Ikeja. There is evidence unicausal relationship between exchange rate and property return in Ikeja and Surulere.

Table 15: Granger Causality Test

Null Hypothesis:	Ikeja F-Stat	(Prob)	Surulere F-stat.	(Prob)
REAL_GDP does not Granger Cause RETURN	0.1909	0.8303	0.4310	0.6660
RETURN does not Granger Cause REAL_GDP	0.2251	0.8040	1.3184	0.3266
INTE_RATE does not Granger Cause RETURN	0.2493	0.7860	2.8168	0.1266
RETURN does not Granger Cause INTE_RATE	0.0218	0.9785	1.2657	0.3395
EXCH_RATE does not Granger Cause RETURN	2.8859	0.0212	3.1038	0.0125
RETURN does not Granger Cause EXCH_RATE	1.0582	0.3967	0.1457	0.8669
INFLATION does not Granger Cause RETURN	0.1757	0.8424	1.3868	0.3109
RETURN does not Granger Cause INFLATION	0.1145	0.8934	3.2634	0.0997
EMPLOY_RATE does not Granger Cause RETURN	0.2919	0.7555	0.9669	0.4258
RETURN does not Granger Cause EMPLOY_RATE	0.1123	0.8953	2.7141	0.1341
UNEMPL_RATE does not Granger Cause RETURN	6.2325	0.0279	0.2587	0.7791
RETURN does not Granger Cause UNEMPL_RATE	0.6687	0.5423	2.5586	0.1465

The result of eagle-granger cointegration test is presented in Table 5.

Table 5: Eagle Granger Cointegration Test

3B/R Markets	Dependent	tau-statistic	Prob.*	z-statistic	Prob.*
Ikeja	RETURN	-5.3377	0.086	30.375	0.000
	REAL_GDP	-3.6781	0.753	-14.447	0.639
	INTE_RATE	-5.5509	0.454	30.525	0.000
	EXCH_RATE	-7.2013	0.019	-19.926	1.000
	INFLATION	-7.2529	0.044	-21.098	1.000
	EMPLOY_RATE	-4.3220	0.558	36.693	0.000
	UNEMPL_RATE	-3.9023	0.682	-14.789	0.526
Surulere	RETURN	-3.6081	0.889	47.8065	0.000
	REAL_GDP	-4.2804	0.587	-15.181	0.420
	INTE_RATE	-5.0717	0.161	-18.589	1.000
	EXCH_RATE	-3.9817	0.741	-15.733	0.303
	INFLATION	-5.5042	0.025	-82.707	0.000
	EMPLOY_RATE	-5.1040	0.010	-17.784	0.890
	UNEMPL_RATE	-3.3074	0.802	-36.742	0.000

The tau- statistic and z-statistics reject null hypothesis of no cointegration among the variables at 5%. With a given sample size probabilities and critical values, therefore there is evidence of two cointegrating equations using tau-statistics (exchange rate and inflation are cointegrated) and there is evidence of three cointegration equations using z-statistics (i.e return, interest and inflation are cointegrated) in Ikeja at 5% level of significance. In Surulere, there is evidence of two cointegrating equations using tau-statistics (i.e inflation and employment) and there is evidence of three cointegration equations using z-statistics (i.e return, inflation and unemployment are cointegrated) at 5% level of significance.

Implication of Findings and Conclusion

The result of granger causality test found a bi-causal relationship between exchange rate and office return suggested that employment and unemployment rates unilaterally granger cause office returns in Ikeja. inflation and unemployment rates unilaterally granger cause office return in Surulere and Ikeja respectively, this finding is consistent with that of Wei & Morley (2012). But there is no evidence of bi-causal relationship among other variables across the markets. The result of eagle granger cointegration test suggests that there is long run relationship between macroeconomic variables and office returns in the markets, this result is consistent with findings from previous studies (Feng *et al.*,2010; Siband and Mhlanga, 2013). Therefore the implication of this outcome is that property investors tend to have an increase in property returns whenever positive macroeconomic policy is made to secure the economy by improving GDP base, increasing exchange rate to encourage local demand, the increase in employment rate increases the purchasing power in housing market, increase in interest and inflation rates increase the housing rent and prices thereby positively influence the investor's return, property return is negatively influenced by negative policy-action that meant to increase unemployment in the economy, therefore any development in economy must be continuously monitored to determine how such development affect office return.

Reference

Apergis, N. (2003). Housing Price and Macroeconomic Factor: Prospect Within the European Monetary Union. *International Real Estate Review. 6(1), 63-74.*

Apergis, N. & Rezitis, A. (2003). Housing Price and Macroeconomic Factor: Prospect Within the EMU. *International Journal of Real Estate. 6(2), 1-12.*

Belo, M. & Abgatekwe, A. (2002). *Project Management in Property Development*: the Nigeria experience. Ibadan: University Press PLC.

Boffoe-Bonnie, D. (1998). The Dynamic Impact of Macroeconomic Aggregate on Housing Prices and Stock of Houses: A National and Regional Analysis. *Journal of Real Estate Finance and Economics. 17(2), 179-197*.

Brooks, C. (2002). Introductory to Econometric for Finance. Cambridge: University Press PLC

Born, W. & Pyhrr, S. (1994). Real Estate Valuation: The Effect of Market and Property Cycles. *Journal of Real Estate Research. 4(3), 455-485.*

Brook, C. & Tsolacos, S. (2001). Linkages between Property Return and Interest Rate. Evidence for the UK. *Journal of Applied Economics. 33(6), 711-719.*

Clark, A. & Daniel, T. (2006). Forecasting South Africa House Price. *Journal of investment analysts. 64(3), 27-33.*

Dabara, D.I. (2014). The Inflation-Hedging Performance and Return Characteristic of Residential Property Investment in Gombe, Nigeria. *AIR 3(1), 71-83*.

Dehesh, A. & Pugh, C. (1998). Property Cycles in a Global Economy. Urban studies. *Journal of Real Estate Research. 37(13), 2581-2602.*

Fraser, W.D. (1993). *Principles of Property Investment and Pricing*. London: The Macmilland Press Ltd.

Ge, X.J. (2009). Determinant of House Price in New Zealand. University of Technology Sydney. *Pacific Rim Property Research Journal. 5(1), 90-121.*

Giussani, B., Hsai, M. & Tsolacos, S. (1992). A Comparative Analysis of the Major Determinants of Office Property Value. *Journal of Property Valuation and Investment. 11(2), 157-173*.

Kwangware, B. (2010). The Impact of Macroeconomic and Financial Factor on the Performance of The Housing Property Market in South Africa. Department of Economics and Economic History: *Rhodes University Conference. Grahamstorm*.

Ling, D. & Naranjo, A. (1997). Economic Risk Factor and Commercial Real Estate Returns. *Journal of Real Estate Finance and Economics. 14(3) 283-307.*

Miregi, M.O. & Obere, A. (2014). Effect of Market Fundamental Variable on Property Prices in Kenya- A Case of Nairobi Residential Property Market. *Journal of Economics and Finance. 5(5), 101-113.*

Muellbauer, J. & Murphy, A. (1997). Boom and Burst in the UK Housing Market. *The Economic Journal. 107(5), 1701-1727.*

Ojetunde, I. (2013). Revisiting Interaction between the Nigeria Residential Property Market and the Macro Economy. International Federation of Surveyor*: Journal of Geography, Environment and Planning. 7(2), 45-60*.

Ojetunde, I, Popoola, N. & Kemiki, O. (2011). On the Interaction between the Residential Property Market and the Macro Economy: *Journal of Geography, Environment and Planning. 7(1), 51-63.*

Peng, R. & Hudson-Wilson, S. (2002). Testing Real Estate Price Bubble*: An Application to Tokyo Office Market. Preceedings of 7th conference in Seoul*.

Roe, B., Irwin, E. & Hazel, A. (2004). The Effect of Farmland Preservation, And Other Neighborhood Amenities on Housing Value and Residential Growth. *Journal of Land Economics. 80(1), 55-75.*

Sinbad, M. & Mhlanga, R. (2013). The Interaction between Property Return and the Macro Economy. *International Journal of Business and Social Research. 3(4), 146-152*.

Udoekanem, N.B., Ighalo, J.I. & Nuhu, M.B. (2014). Determinants of Commercial Property Rental Growth in Minna, Nigeria. *EUL Journal of Social Science. 5(1), 60-75.*

Udoekanem N.B, Ighalo J.I, Sanusi Y.A & Nuhu M.B (2015) Office Rental Determinants in Wuse Commercial District of Abuja, Nigeria. *University of MauritiusResearch Journal. 21(2), 1-26.*

Umeh, O.L. & Oluwasore, O.A. (2015). Inflation Hedging Abilities of Residential Properties in Selected Area of Ibadan Metropolis, Nigeria. *ATBU Journal of Environment of Technology. 8(2): 93-106.*

Wei, Q. & Morley. B. (2012). The Interaction between the Macro Economy and House Price Return. *Journal of Property Return. 17 (8), 1-17.*

Wahab, M. B., Ola, O. S., Sule A. I., Adepoju, A. S. & Dodo, Z. U. (2018) Inflationary Hedging Capacity of House Price Returns in Emerging Economy of Nigeria *LAÜ Sosyal Bilimler Dergisi (IX-II): 152-166 jss@eul.edu.tr* http://dergipark.gov.tr/euljss **http://en.lau.edu.tr/euljss/**

Wahab, M.B Adeogun, A.S Morenikeji, G.B. Mammah. M & Abdulkareem S.O (2017) Effect of Macroeconomic Factors on Residential Property Returns in Abuja, Nigeria *EUL Journal of Social Sciences 8(2),133-149.*

Factors Affecting Real Estate Project Delivery and Housing Affordability in Abuja

Emokpaire, E.[a] & Mohammed, M.[b]
Department of Project Management Technology, Federal University of Technology, Minna
[a]emokpaireenahoro@gmail.com

Abstract:

This study focuses on the factors affecting real estate project delivery and housing affordability in Abuja, Nigeria. The study adopted a purposive sampling technique where 200 questionnaires was distributed to construction professionals and 178 was retrieved and analysed using SPSS. Findings revealed that the most significant factors affecting real estate project delivery are access to land, finance/funding, cost of building materials, high cost of capital, government policies, and high cost of labour. Also, the most significant factors affecting housing affordability in Abuja are cost of land, household income, house rent, housing expenditure, residential property price and housing preference. Hence, to increase housing affordability in Abuja, policymakers and other stakeholders may consider implementing strategies that address the factors identified as significant in the study. For example, measures to reduce the cost of land, such as land-use planning policies, or incentives for developers to build on underutilized land, could help to decrease the overall cost of housing. Similarly, policies that aim to increase household income, such as job training programs, or wage increases, could also help to improve housing affordability by increasing the ability of households to afford housing.

Keywords: Real Estate, Housing Affordability, Project Delivery

INTRODUCTION

Housing plays an important role in the development of any nation (Muhammed *et al*., 2022). It had been ascertained as the basic need of a man (Makinde, 2013; Akinyode and Tareef, 2014). It is the constitutional responsibility of every government to provide an affordable housing to its citizenry. The Nigerian government being faced with limited resources in the fulfilment of this responsibility resort to succour from private organisation (Adediran *et al*., 2020). In Nigeria, estate developers and the private sector has contributed about 90% of urban housing (Omole, 2001), to assist the government as a result of rapid growth in the urban areas. Despite this, estate developers are faced with the constraints of meeting up the supply of housing (Nubi, 2008; Adegoke and Agbola, 2020), especially in the modern cities such as Abuja metropolis. This is due to the cost of building materials, deficiency of housing finance arrangement, inflexible loan conditions from mortgage banks and government policies (Raji, 2008; Enisan and Ogundiran, 2013) which induced insufficient funding (Ihuah and Fortune 2013; Ihuah and Eaton 2013; Dorosaimy *et al*., 2015; Tijani and Ajagbe 2016; Mac-Barango, 2017). As a result, housing deficit in Nigeria was put at about 16 million units, in 2009 with a rough estimate of USD40 billion to handle it (Basorun and Fadairo, 2012), this further upsurge by an additional 2 million in 2013 to make 18 million shortages among the 200.96 million population reported by the world population review 2019 owing to the negligence of government towards the housing sector as well as the inability of the estate developers to deliver to sufficiency housing needs of the people (Adediran *et al*., 2020). Consequently, Nwachukwu and Nzotta (2010) and Desai (2012), opined that the rate at which real estate projects fail, or are abandoned, is retrogressive in most developing economies.

However, Iben and Aduwo (2013) asserts that the provision of satisfactory housing that meets government prescribed standards of quality and user needs, expectations and aspiration has always been the goal of every public housing programme in Nigeria. Conversely, Adeshina (2010) opines that the causes of the lack of housing affordability resulting from the insufficient delivery of estate projects includes inadequate/improper planning and inflation. Also, poor timing (Ihuah and Benebo (2014); poor estimation of project duration (Adediran *et al*., 2020); bankruptcy of contractor and incompetent project managers (Mac-Barango, 2017); wrong estimates and variation of project scope (Ibem and Aduwo, 2013), faulty designs, unrealistic cost planning and control at the design stage (Gana and Olorunfemi, 2015); delaying in payment, poorly developed clients' brief and working drawings (Olusegun and Michael, 2011); lack of stake holders' involvement and lack of organized work program planning

(Agyemang and Morrsion, 2018), among others are also seen as failure inducing factors. These factors are part of the many which have therefore, induced the inability of the estate developers to deliver project to the sufficient needs of the populace within Abuja metropolis. Several studies have been conducted on the real estate delivery and affordable housing (Ibem and Aduwo, 2013; Agbola and Adegoke, 2017; Adegoke and Agbola 2020). Empirically, only few studies have been conducted in Abuja, Nigeria. Therefore, this paper seeks to study the factors affecting real estate project delivery and housing affordability in Abuja, Nigeria.

LITERATURE REVIEW

According to Ajayi *et al*. (2016), the factors affecting housing estate project delivery include land inaccessibility challenges, increasing construction cost, progressive rise on poverty, stunted financial and mortgage system, policies of government and poor bureaucratic procedures, building materials unabated price increment, population increase, insufficiency of physical planning, statutory regulation and bye-laws, and issues with development control units. Also, Alao and Jagboro (2017), identified the most significant causes of project abandonment and stated issues such as payment delays, fund mismanagement, insufficient budg*et* allocation, insufficient finance, contractors' inflation, and bankruptcy. They also explored four significant components, including stakeholders' response capacity, poor financial management, improper planning and monitoring, and unexpected occurrences. In a study also performed in Nigeria with a different kind of project, there were some similar results with the study of Alao and Jagboro (2017), that owners' insufficient finance, contractors' bankruptcy, and business failure were considered as the significant factors to the failure and abandonment of multi-storey building projects. Other significant factors found in the study of Adebisi *et al*. (2018), were improper planning at the preconstruction phase, improper scheduling of building project activities, structural failure during construction, and qualified professionals' lack of involvement. The failure and abandonment factors were then grouped into five components, namely, capability of human resources, contractor selection and variation, planning and structural quality, insecurity and variation, and force majeure and political risk (Adebisi *et al*., 2018).

Consequently, in other nations, Ikediashi *et al*. (2014), in Saudi Arabia, posited poor risk management to be the paramount failure factor for infrastructure projects, followed by budget overruns and poor communication, respectively. Alaloul *et al*. (2016), investigated failure factors of a public-private partnership (PPP) in the UAE and found that lack of appropriate skills, poor communications between private partners, high project value, and high participation cost were the most critical failure factors. However, a study by Trangkanont and Charoenngam (2014) on critical failure factors of PPP low-cost housing program in Thailand showed that critical failure factors were ineffective change management of public clients, undermined organizational culture and staff's behaviour of public clients, inappropriate contractors, poor bidding documents, difficulties of low-income groups, political risks, economic crisis, and limitations of housing finance. Another study was also performed to identify failure factors of road infrastructure PPP projects in India (2017). The results of this study concluded that public protest, political parties, influence of higher authorities, force majeure, and maintenance cost overruns were the most responsible factors for the failure of road PPPs in the planning stage, development stage, procurement stage, construction stage, and operation and maintenance stage, respectively, while in the study of Ikediashi *et al*. (2014) in Saudi Arabia, poor risk management was found to be the paramount failure factor for infrastructure projects, followed by budget overruns and poor communication, respectively. Ofori (2000), showed that construction industries in developing countries faced many problems such as resource constraints, lack of technical and managerial capability, lack of knowledge, short-term orientation and lack of focus on construction, falling exchange rates and rising inflation. These problems were found to be critical failure factors of construction projects in previous studies (Nguyen & Chileshe, 2015; Damoah & Kumi 2018; Trangkanont & Charoenngam 2014; Alaloul *et al*. 2016; Alao & Jagboro, 2017). These failure factors to construction projects differ from one country to another, due to the different characteristics of each country, such as culture, economic conditions, or technology advancement.

METHODOLOGY

The methodology involved a descriptive survey with a structured questionnaire administered to construction industry practitioners in FCT, Abuja. This study adopted a non-probability sampling technique known as 'purposive sampling' to select its respondents. A total of 200 questionnaires were administered, out of which 178 (89% response rate) was returned. The questionnaire was divided into three parts: the first part was dedicated to the respondents' background; the second part was related to questions on factors affecting real estate project delivery; while the third part was related to questions on factors affecting housing affordability. A five-point likert scale was used with each point representing different levels of agreement and disagreement. The mean score and relative importance index (RII) were used to analyze the findings amongst these factors. RII has been used in construction related research by such authors like Babatunde *et al.* (2010); Fugar and Agyakwah-Baah (2010); and Amade (2016). Microsoft Excel and the Statistical Package for Social Sciences (SPSS) software were the statistical tools adopted for analysis.

RESULTS AND DISCUSSION

Background Data of Respondents

The data analysis was based on 178 valid questionnaires (89% return rate) retrieved from 200 administered questionnaires. The background data of respondents is presented in Table 4.1.

Table 4.1: Background Data of Respondents

Profile	Frequency	Percentage (%)
Educational Qualification		
NCE/ND	6	3
HND/BSC	118	59
MBA/MSC/M. Eng	61	30.5
PhD	15	7.5
Industry Professionals		
Project Manager	46	23
Engineer	30	15
Architect	26	13
Quantity Surveyor	33	16.5
Builder	28	14
Contractor	22	11
Others	15	7.5
Years of Experience		
1 – 5	26	13
6 – 10	31	15.5
11 – 15	52	26
16 – 20	63	31.5
0ver 20	28	14

The results of the educational qualifications showed that 3% had NCE/ND, 59% had a first degree and its equivalent, 30.5% had a master's degree and 7.5% had PhD. It indicates that HND/BSC may be the requisite qualification for practitioners in the industry. Also from the results, Project Managers constituted 23%, Engineers (15%), Architect (13%), Quantity Surveyor (16.5%), Builder (14%), Contractor (11%) and others (7.5%). Project managers may be the most professionals in the construction industry. About 31.5% of the respondents had experience spanning 16 – 20 years while 13% had the least experience of 1 – 5 years. This result implies that construction professionals are experienced in their various fields; as a result, the data obtained is reliable, valid and suitable.

Factors Affecting Real Estate Project Delivery in Abuja

Based on the results presented in Table 4.2, it appears that the respondents agree that the most significant factors affecting real estate project delivery are access to land, finance/funding, cost of building materials, high cost of capital, government policies, and high cost of labour. These factors had a relative importance index (RII) value of 0.97, 0.93, 0.90, 0.88, 0.86, and 0.84, respectively, indicating that the respondents considered them to be highly significant.

Table 4.2: Factors Affecting Real Estate Project Delivery in Abuja

Factors	Mean	RII	Rank
Access to Land	4.87	0.97	1
Finance/Funding	4.65	0.93	2
Cost of Building Materials	4.54	0.90	3
High Cost of Capital	4.40	0.88	4
Government Policies	4.32	0.86	5
High Cost of Labour	4.21	0.84	6
Corruption	4.15	0.83	7
Consumer Low Purchasing Power	4.06	0.81	8
Development Control	3.72	0.74	9
Knowledge on Estate Development	3.31	0.66	10

Access to land is a crucial factor in real estate project delivery, as developers need to acquire land in order to build on it. The availability and cost of land can impact the feasibility of a project, as well as the overall timeline and budget. Finance/funding is another key factor, as developers need access to sufficient funding to purchase land, hire workers, and purchase materials. The cost of capital, or the cost of borrowing money, can also have a significant impact on the feasibility and affordability of a project. The cost of building materials and labour can also affect the delivery of real estate projects. If these costs are high, it can impact the overall budget and profitability of the project. Government policies can also have an impact on real estate project delivery, as developers must comply with various regulations and requirements. Changes in these policies can affect the timeline and feasibility of a project. These findings are in agreement with Wuyokwe & Yakubu (2022) and Ajayi *et al.* (2016) which showed that problem of land inaccessibility, building materials, high cost of capital stunted financial and mortgage system were the factors affecting housing delivery in Nigeria. According to Milala *et al.* (2020) and Ahmed (2022), access to suitable land, however, poses a substantial obstacle to the increases in real estate in this world region, which has an influence on project timetables, development expenses, and, therefore, development prices.

Factors Affecting Housing Affordability in Abuja

The respondents were asked to indicate their opinion on the level of their agreement with the identified factors affecting housing affordability based on their experience in their organizations/fields. The results presented in Table 4.3 indicates that the most significant factors affecting housing affordability in Abuja are cost of land, household income, house rent, housing expenditure, residential property price and housing preference with an RII value of 0.98, 0.94, 0.93, 0.90, 0.88 and 0.86 respectively.

Table 4.3: Factors Affecting Housing Affordability in Abuja

Factors	Mean	RII	Rank
Cost of Land	4.88	0.98	1
Household Income	4.72	0.94	2
House Rent	4.67	0.93	3
Housing Expenditure	4.50	0.90	4
Residential Property Price	4.42	0.88	5
Housing Preference	4.31	0.86	6
Increase in Population	4.25	0.85	7
Demographics	4.15	0.83	8
Lack of Price Control	4.03	0.81	9
Perception of Buyer	3.87	0.77	10
Government Intervention	3.65	0.73	11

The cost of land is a significant factor in determining the overall cost of housing. Higher land costs can make it more expensive to build new housing or to purchase existing homes, which can make housing less affordable for potential buyers or renters. Household income is an important factor in determining housing affordability. Higher incomes generally allow individuals or households to afford higher housing costs, while lower incomes may make it more difficult to afford housing. Furthermore, house rent, or the cost of renting a home, is another factor that can affect housing affordability. Higher rent costs can make it more difficult for individuals or households to afford suitable housing. Housing expenditure refers to the amount of money that individuals or households spend on housing-related costs, such as mortgage payments, utilities, and maintenance. Higher housing expenditure can make it more difficult for individuals or households to afford other necessities or to save for the future. The price of residential property, or the cost of purchasing a home, can also affect housing affordability. Higher property prices can make it more difficult for individuals or households to afford to purchase a home. Housing preference refers to the type of housing that individuals or households prefer. Some individuals or households may prefer more expensive housing options, such as larger homes or homes in certain neighbourhoods, which can affect their ability to afford housing. These findings are in agreement with Akinyode (2017), Ezennia & Hoskara (2019), and Wuyokwe & Yakubu (2022) who opined that the revealed house rents, housing preference, housing satisfaction, land price and government intervention are the determining factors for housing affordability.

CONCLUSIONS

The major factors affecting real estate project delivery and housing affordability in Abuja are: Access to land, access to finance funding, cost of building materials, high cost of capital, government policy, high cost of labour, corruption, consumer low purchasing power, development control, knowledge on estate development.

Better government bureaucratic process will help to increase housing affordability in Abuja. Policymakers and other stakeholders may consider implementing strategies that address the factors identified as significant in the study. For example, measures to reduce the cost of land, such as land-use planning policies or incentives for developers to build on underutilized land, could help to decrease the overall cost of housing. Similarly, policies that aim to increase household income, such as job training programs or wage increases, could also help to improve housing affordability by increasing the ability of households to afford housing. Other potential strategies could include efforts to decrease the cost of building materials, such as through import tariffs or subsidies, or measures to increase the supply of affordable housing, such as through the construction of public or low-income housing. It is important to carefully consider the specific context and needs of the housing market in Abuja when designing and implementing these strategies in order to maximize their effectiveness.

REFERENCES

Adebisi, E. O., Ojo, S. O. & Alao O. O. (2018). "Assessment of factors influencing the failure and abandonment of multistorey building projects in Nigeria," International Journal of Building Pathology and Adaptation, vol. 36, no. 2, pp. 210–231.

Adediran, A. O., Oladejo, S. O. & Ijagbemi, C. O. (2020). The Fundamentals to Affordable Home-Ownership in Nigeria. Journal of Multidisciplinary Engineering Science and Technology (JMEST). Vol. 7 Issue 4.

Adegoke, S. A. O. & Agbola, T. (2020). Housing Affordability and the Organized Private Sector Housing in Nigeria. Open Journal of Social Sciences, 8, 177-192. https://doi.org/10.4236/jss.2020.

Adeshina, R. (2010). "Abandonment of Construction Projects,". Journal of emerging Trends in Economics and Management Science, vol. 2, no. 2, pp. 142-145.

Agbola, B. S. & Adegoke, S. A. O. (2017). Residential Satisfaction and the Organised Private Sector Housing in Nigeria. International Journal of African and Asian Studies.

Agyemang, F. S. & Morrison, N. (2018). "Recognising the barriers to securing affordable housing through the land use planning system in Sub-Saharan Africa: A perspective from Ghana." Urban Studies 55(12): 2640-2659.

Ajayi, O., Ajayi, O., Akinsiku, O., & Osunsanmi, T. (2016). Strategies for housing affordability in Nigeria. *Journal of construction project management and innovation*, *6*(sup-1), 1620-1632.

Akinyode, B. F. & Tareef, H. K. (2014). Bridging the gap between housing demand and housing supply in Nigerian urban centres. A review of Government intervention so far. British Journal of Arts and Social Sciences, 18(2), 94 – 107.

Akinyode, B. F. (2017). Determining factors for housing affordability in Ibadan, Nigeria. *Ethiopian Journal of Environmental Studies and Management*, *10*(5), 642-653.

Alaloul, W. S., Liew, M. S. & Zawawi, N. A. BWA. (2016). "A framework for coordination process into construction projects," MATEC Web of Conferences, vol. 66, p. 00079.

Alao, O. O. & Jagboro, G. O. (2017) "Assessment of causative factors for project abandonment in Nigerian public tertiary educational institutions," International Journal of Building Pathology and Adaptation, vol. 35, no. 1, pp. 41–62.

Amade, B., Akpan, E. O. P., Ubani, E. C., & Amaeshi, U. F. (2016). Supply chain management and construction project delivery: Constraints to its application. *Project Management World, 5*(5), 1-19.
Damoah, I. S. & Kumi, D. K. (2018). "Causes of government construction projects failure in an emerging economy," International Journal of Managing Projects in Business, vol. 11, no. 3, pp. 558–582.
Doraisamy, S. V., Akasah, Z. A. & Yunus, R. (2015). A Review on Abandoned Construction Projects: Causes & Effects. Applied Mechanics and Materials. Vols. 773-774; pp 979-983.
Enisan, Olugbenga & Ogundiran, Adekemi (2013). Challenges of Housing Delivery in Metropolitan Lagos.*Research on Humanities and Social Sciences*, 3 (20), 1 – 8.
Ezennia, I. S., & Hoskara, S. O. (2019). Exploring the severity of factors influencing sustainable affordable housing choice: evidence from Abuja, Nigeria. *Sustainability*, *11*(20), 5792.
Gana, A. J. & Olorunfemi, K. O. (2015). "Human Elements and factor contribution and consideration in construction Projects towards completion (the Nigeria Experience)," International Research Journal of Engineering Science, Technology and Innovation, vol. 4, no. 1, pp.12-18.
Ibem, E. O. & Aduwo, E. B. (2013). Assessment of Residential Satisfaction in Public Housing in Ogun State, Nigeria. Habitat International Vol.40 pp/66 – 175.
Ihuah, P. W. & Benebo, A. M. (2014). "An Assessment of the Causes and Effects of Abandonment of Development Projects on Real Property Values In Nigeria," International Journal of Research in Applied, Natural and Social Sciences, Vol. 2, Issue 5, pp. 25-36, 2014.
Ihuah, P. W. & Eaton, D. (2013). "A Framework for the Sustainable Management of Social (Public) Housing Estates in Nigeria: a pilot study," A Paper Presented at RICS COBRA Research Conference, New Delhi, India.
Ihuah, P. W. & Fortune, J. C. (2013). "Toward a Framework for the Sustainable Management of Social (Public) Housing Estates in Nigeria. "Journal of US-China Public Administration, vol. 10, no. 9, pp. 901-913, 2013.
Ikediashi, D. I., Ogunlana, S. O. & Alotaibi, A. (2014). "Analysis of project failure factors for infrastructure projects in Saudi Arabia: a multivariate approach," Journal of Construction in Developing Countries, vol. 19, no. 1, pp. 35–52.
Mac-Barango, D. (2017). "Construction Project Abandonment: An Appraisal of Causes, Effects and Remedies," World Journal of Innovation and Modern Technology. vol. 1, no. 1, 2017.
Makinde, O. O. (2013). Housing delivery system need and demand. *Environment Development Sustainability,* 16, 49 – 69.
Muhammed, A. O., Muhammed, A. A., Yakubu, H. A., Suleiman, A., & Adam, A. (2022). Assessment of Factors Affecting Contractors Tendering Success for Construction Projects in North-Central Nigeria. *International Journal of Real Estate Studies*, 16(1), 87–99. https://doi.org/10.11113/intrest.v16n1.155
Nguyen, T. P. & Chileshe, N. (2015). "Revisiting the construction project failure factors in Vietnam," Built Environment Project and Asset Management, vol. 5, no. 4, pp. 398–416.
Nubi, O. T. (2008). Affordable housing delivery in Nigeria. The South African Foundation International conference and exhibition, Cape Town, October, 1- 18.
Nwachukwu, C. C. & Nzotta, S. M. (2010). "Quality Factor Indexes: A Measure to Project Success Constraints in A Developing Economy". Interdisciplinary Journal of Contemporary Research in Business, vol. 2 no. (2), pp. 1-8.
Ofori, G. (2000). "Challenges of construction industries in developing countries: lessons from various countries," in Proceedings of 2nd International Conference on Construction in Developing Countries: Challenges Facing the Construction Industry in Developing Countries, vol. 5, no. 24, pp. 15–17, Gaborone, November.
Omole, F. K. (2001). Urban renewal process issues and strategies. Ikeja: Concept books and Publication Company Limited.
Raji, O. (2008). Public and Private developers as agents in urban housing delivery in sub–Saharan Africa: The situation in Lagos State. *Humanity of Social Sciences Journal*, 3 (2), 143- 150.
Tijani, M. A. & Ajagbe, W. (2016). "Professional views on the causes and effects of construction projects abandonment in Ibadan Metropolis, Nigeria," Ethiopian Journal of Environmental Studies and Management. vol. 9, no. 5, pp. 593-603.
Trangkanont, S. & Charoenngam, C. (2014). "Critical failure factors of public-private partnership low-cost housing program in Thailand," Engineering, Construction and Architectural Management, vol. 21, no. 4, pp. 421–443.
Wuyokwe, G. N., & Yakubu, S. (2022). Exploring the Factors Affecting Property Development and Housing Affordability in Abuja. *Rajasthali Journal*, 1(4), 121-135.

SUB-THEME 2:
MODERN GEOSPATIAL TOOLS FOR EPIDEMIOLOGY

GIS Based Land Suitability Analysis for Optimal Choice of Cereal Crops Production in Kaduna State

Abdulraheem, S.[1,2] & Opaluwa, Y. D.[1]
[1]Department of Surveying and Geoinformatics, Federal University of Technology Minna, Nigeria
[2]Department of Surveying and Geoinformatics, Kaduna Polytechnic, Kaduna State, Nigeria
sharafuddeenabdurraheem@gmail.com; Opaluwayd@futminna.edu.ng
Corresponding author: sharafuddeenabdurraheem@gmail.com

Abstract

Site suitability analysis is a prerequisite for optimal choice of cereal crops production. Effective land use has not only achieved high productivity of crops but also conserves an ecologically balanced environment and maintains the fertility of the soil. Thus, for each region and each specific area, we must study to find suitable land use types as well as proper crop rotation to obtain the highest yields. This paper aimed at evaluating the current land suitability for major cereal crops: rice, sorghum and maize in Kaduna state. Geographic Information System and Remote Sensing technique using multi-criteria evaluation and statistical approach for evaluating the physical land suitability for the major crops. Various physical lands attributes, namely temperature, rainfall, altitude, slope, soil type, accessibility to market and proximity to road and river have been used as input parameters. Physical land suitability maps were generated for the major cereal crops. This paper demonstrated that based on physical land suitability analysis, the study area has huge potential for cereal crop production. Topographic factor (altitude) and climatic factors (temperature and rainfall) are the dominant factors that influence the suitability of agricultural land for the major crops in the study area. Statistical methods (t-test and ANOVA) were also used to estimate and test the suitability of the study area for the production of the selected cereal crops. The suitability analysis in the study area shows that the soil is highly suitable for planting of sorghum. Similarly, Rice is moderately suitable in most part of Kaduna State with suitability value of around 2,285,255.79 (ha). The Maize cultivation is suitable in most part of the study area. Although, it is not suitable in the border town of Chikun Local Government area and fringe part of Kachia with suitability value of 42,756.58 (ha).

Keywords: GIS, Suitability Analysis, Suitable land use**,** Cereal crops

Introduction

Land evaluation method is a systematic method which evaluates the potential of lands in order to find the best region for cultivating some special crops. Theoretically, the potential of land suitability for agricultural use is estimated through an evaluation process which uses criteria such as climate, soil, water resources, topography, components of the environment, and understanding the local environment (Ceballos-Silva & Ľopez-Blanko, 2003). Cereal crops such as maize, sorghum, millet and rice are the major cash crops grown in Kaduna state. However, the effects of climatic change and crop insecurity (due to grazing of cattle, banditry activities and crop diseases) have continued to threaten cereal crops farming. This has a declining effect on the nation's GDP. This paper tries to presents land suitability analysis for selecting suitable sites for cereal crops farming in Kaduna State.

Although, several studies have been conducted in different parts of the world but such studies are inadequate to make decision on suitable cereal crops farming in Kaduna State. This is because locally adapted evidence from the combination of topographic, soil, climatic and crop safety factors is needed within the state. Consequently, this paper incorporates the effect of climatic change and crop safety in to the study for selection of suitable sites for cereal crops farming.

Crop selection for sustainable and effective agricultural land management has to take into accounts several issues such as chemical, physical, environmental, economic and social conditions. Especially after land consolidation projects, sustainable agricultural crop management should be investigated for each crop which are suitable for the project area to benefit from the land consolidation contributions such as irrigation, roads, modified parcel boundaries and surfaces. Thus, Geographical Information Systems (GIS) aided suitability analysis techniques are required to determine the suitable crops for the consolidated areas. (Fatih and Fatma 2021). In this paper, Geographic Information System (GIS) and Remote Sensing (RS) methods are integrated to determine the suitability of maize, rice and sorghum which are some of the major cereal crops in the study area. Descriptive (mean and standard deviation) and inferential (t-test and ANOVA) statistical method were applied to the data generated for an informed decision making. Therefore, this paper aimed at conducting land suitability analysis for optimal choice of cereal crops production.

2. Materials and Methods

The data used for this study includes remotely sensed satellite imagery (Landsat 8 OLI), SRTM DEM and Climatic Research Unit (CRU) Data of University of Eastern Anglia (UEA) USA, and conventional maps. The data and their sources are display in Table 1.

Table 1: Data features and their sources

S/N	TYPES OF DATA	SOURCE	SCALE/RESOLUTION
1	SRTM DEM	USGS Earth Explorer portal	30 metres resolution
2	Rainfall image	Climate Research Unit (CRU) Data portal, University of Eastern Anglia (UEA) USA.	15 metres resolution
3	Landsat 8 (OLI)	USGS Earth Explorer portal	
4	Soil Data	FAO Soil Map and SWAT Data base	1:50000
5	Road map	Open street map (OSM)	1:50000
6	Temperature raster Data	Climate Research Unit (CRU) Data portal, University of Eastern Anglia (UEA) USA.	15 metres

Global Positioning System (handheld GPS) was used for field collection of selected point's coordinate, digital camera for imaging of observed features such as markets, roads, rivers etc. ArcGIS 10.5 was employed for digitizing and Suitability analysis, while ERDAS IMAGINE 2015 was utilized for image processing and classification.

2.1 Creation of thematic layers for crop suitability

- **Annual average rainfall map**

An average annual rainfall imagery of the study area for 2020 was downloaded from Climate Research Unit of University of Eastern Anglia and the average annual rainfall was interpolated using the Inverse Distance Weighing (IDW) method. This was done by importing the rainfall imagery into ArcGIS and converted from netcdf to tif. The rainfall imagery was processed using composite band tool for rainfall band separation, cell statistics tool was used to generate annual map and DW interpolation of the spatial analyst toolbox was finally used to produce the average annual rainfall data.

- **Annual mean temperature map**

An annual mean temperature imagery of the study area for 2020 was downloaded from Climate Research Unit of University of Eastern and the IDW interpolation was used to produce the annual mean temperature.

2.2 The Spatial Factors for crop suitability analysis

Multi-Criteria Decision Making (MCDM) as a methodology for suitability assessment within the Spatial Decision Support System. It is a well-known branch of decision-making techniques that logically structure and evaluate problems with multiple attributes and objectives. Based on MCDM approach, various physical lands attributes, namely temperature, rainfall, altitude, slope, soil, accessibility to market and proximity to road and river were used as input parameters to generate a physical land suitability map for the major cereal crops.

I. Slope

Slope is an important parameter in crop suitability studies. The slope elements, in turn are controlled by climatomorphogenic processes in the area having the rock of varying resistance. The slope map of study area was generated from Shuttle Radar Topographic Mission (SRTM) digital elevation model (DEM) data with a standard pixel size of 30m using slope tool of spatial analyst tool in ArcGIS environment.

II. Topographic elevation map

These data are freely available from the United State Geological Survey (USGS) platform (earthexplorer.usgs.gov). Four tiles of SRTM were downloaded, merged to new mosaic raster, and reprojected to Universal Transverse Mercator (UTM) projected coordinate system with WGS 1984, 32N Datum. Elevation map of the study area was directly derived by classifying the filled and reprojected DEM into five elevation classes (<500m flat, 612m slightly sloppy, 711m inclined, 870m moderately steep and >1363m steep) based on the study area topography.

III. Soil types

Soil classes play a distinguished role on the amount of water that may infiltrate into the soil. The soil texture, chemical and hydraulic characteristics are the most factors thought about for estimation of rate of infiltration and ability of crop to grow on the soil. The existing Food and Agriculture Organization soil map in digital format and Soil Water Assessment Tool (SWAT) soil database was employ. ArcGIS 10.5 was used to create soil type through sequential steps that was begin with reprojected to Universal Transverse Mercator (UTM) projected coordinate system with WGS 1984 32N Datum, clipping of FAO soil map with the study area shape files and finally, classifying soil types using SWAT soil database.

IV. Road proximity

The road data for the study area was downloaded from open street map website to extract it to shape file and later covert it into raster in order to be used as crops suitability parameter. Proximity analysis tool multiple ring buffering was used to classify road into five proximity criteria as 2 km, 2–4 km, 4–7 km, 7-10 km and 10-15km. These were classified as highly suitable, moderately suitable, marginally suitable, less suitable and not suitable due to the distance from the road respectively.

V. Market proximity

Proximity to market analysis was carried out using buffering tool proximity analysis which resulted in 0–4 km, 4–8 km, 8–12 km and 12–16 km classified as highly suitable, moderately suitable, marginally suitable and not suitable due to the distance from the cropland, respectively.

VI. **River proximity**

The river map of the study area was extracted from shuttle radar topographic mission (SRTM) elevation data and process using hydrology tool of ArcGIS with series operations fill, flow direction, flow accumulation, map algebra, stream link, stream order, stream to feature).

Proximity analysis tool multiple ring buffer was used to classify river into five proximity classes and later covert it into raster in order to be used as crops suitability parameter. Crop land far from river by 0–500 m, 500–1000 m, 1000–1500 m, 1500-2000 m and 2000-2500 m were classified as highly suitable, moderately suitable, marginally suitable, less suitable and not suitable due to the distance from the cropland, respectively.

3. Results and Discussion

3.1 Sorghum Suitability Analysis

Figure1 shows the analysis of sorghum suitability in the study area. It was found that the soil in the study area is highly suitable for planting of the identified crops with a suitability value covering about 20,716.81(ha) of the land area, it is moderately suitable in most part of Zango Kataf, Kaura and part of Kauru with a suitability value of around 168,156.69 ha of the total land area. It has low suitability In part of Birnin Gwari and Kaura with a suitability value of around 39,784.46 (ha) land area while it is not suitable in the fringe part of Chikun, part of Kachia and exterior part of Birnin Gwari with a suitability value of 27,011.87(ha) land area.

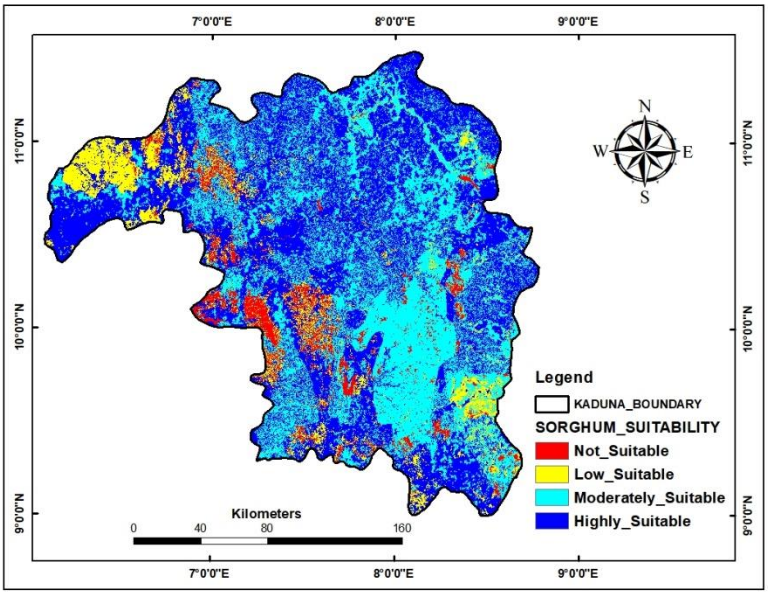


Figure 1: Sorghum suitability map

3.2 Rice Suitability Analysis

Figure2 Shows the rice suitability map of the study area, the classification used in this research are highly suitable, moderately suitable, low suitable and not suitable. Places around Southern Kaduna part of Kachia and Chukun Local Government are highly suitable for the planting of rice around area of suitability value of 335,643 (ha) and part of Kaura and Jammaa Local Government at the same land area. Rice suitability is moderately suitable in most part of Southern Kaduna, places like Kajuru, Kaura, Chikun, Kauru, Jaba, Sanga and Kagarko local government with suitability value of around 2,285,255.79 (ha), it is also suitable in part of Northern Kaduna in places like Ikara, Makarfi, Zaria, Giwa, Kudan and Soba. Rice Low suitability are found around most part of Kaduna Central like Kaduna North and South, Igabi with suitability value of 1,281,941 (ha), from the satellite images analysis most part of Birnin Gwari is not suitable for rice cultivation and part of Kaura in Southern Kaduna with suitability value of 524.121 (ha).

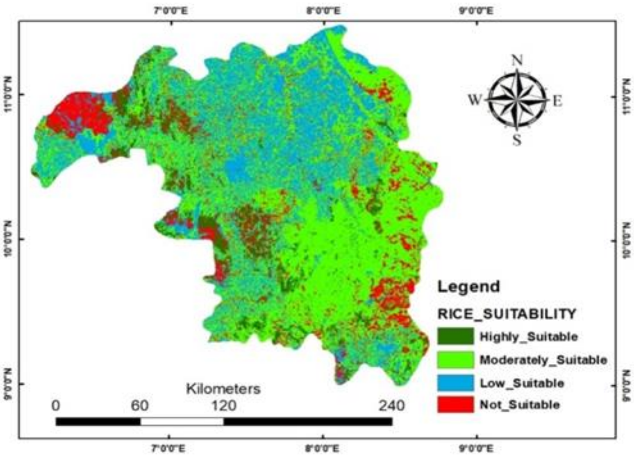


Figure 2: Rice suitability map

3.3 Maize Suitability Analysis

Figure 3 shows the maize suitability analysis in the study area. Most part of northern Kaduna is suitable for maize cultivation. Places like Makarfi, Zaria, Sabon Gari, Giwa, Soba, Kubau, also Kaduna north and south, Birnin Gwari and chikun, part of Kagarko and Jammaa Local Government in Southern

Kaduna with suitability value of 1,984, 388 (ha) areas coverage. Places like Lere, Kaura, Kajuru, Zango Kataf and Kachia Local Government all in Southern Kaduna are moderately suitable for the cultivation of maize in the study area with suitability value covering 1,693,453 (ha). Low suitability are found in part of Birnin Gwari, part of Chikun, the border town of Kagarko with suitability value of around 706, 632.36 (ha). Maize cultivation is suitable in most part of the study area, although it is not suitable in the border town of Chikun Local Government and fringe part of Kachia with suitability value of 42,756.58 (ha).

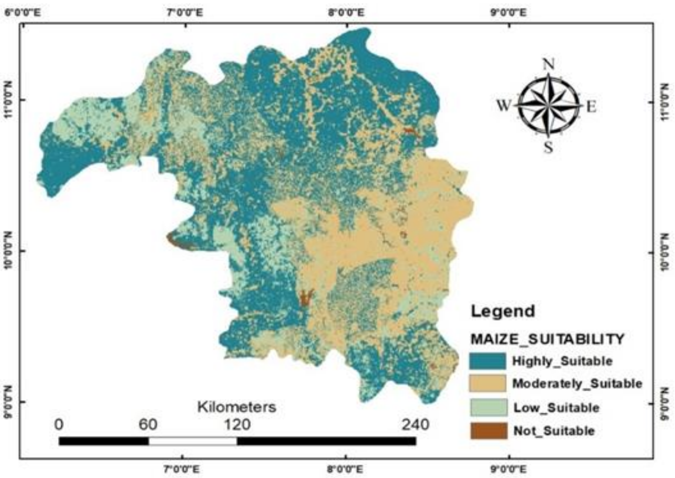


Figure 3: Maize suitability map

Table 2 shows the summary of the classification of areas suitable for the production of the selected cereal crops in Kaduna state.

Table 2: Summary of classification of areas suitable for the production of the selected cereal crops in Kaduna state

Cereal Crops	Maize	Rice	Sorghum
Suitability Classes	Area (ha)	Area (ha)	Area (ha)
Highly Suitable	1,984,388.23	335,643.18	207,716.81
Moderately Suitable	1.693,453.01	2,285,255.79	168,156.69
Low Suitable	706,632.36	1,281,941.39	39,784.46
Not Suitable	42,756.58	524,121.30	27,011.87

From Table 3 below, the suitability of the sites for the selected cereal crops was estimated and compared with a base line mean of 2.5. The estimated mean suitability of maize, rice and sorghum are 3.27, 2.55 and 3.26 respectively. Subjecting them (estimated means) to a statistically significant test (t-test) shows that they are all suitable crops for the study area $p = 0.000 < \alpha = 0.05$,

Table 3: Suitability of the sites for the selected crops using t-test analysis

Suitability	Mean	Std deviation	T-value	Sig (2 tail)
Maize	3.2693	0.75759	2136.813	0.000
Sorghum	2.5495	0.7948	130.482	0.000
Rice	3.2572	0.85865	586.723	0.000

In Table 4 below, further test using Analysis of Variance (ANOVA) technique to compare the suitability of the sites for the selected cereal crops was carried out. The test resulted in retaining the null hypothesis of equality of suitability among the selected crops. $p = 0.120 > \alpha = 0.05$. This implies that all the selected cereal crops are equally suitable for the study area.

Table 4: Suitability of the sites for the selected crops using ANOVA analysis

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	2885231876515.167	2	1442615938257.583	2.712	.120
Within Groups	4787528015921.750	9	531947557324.639		
Total	7672759892436.916	11			

The market proximity using the Euclidean analysis to carry out the distance proximity analysis show a great variation, the values are 0-4 km (11.25%) classified as highly suitable, 4-8 km (21.25%) classified as moderately suitable, 8-12km (30%) classified as marginally suitable and 12-16 (37.5%) classified as not suitable.

The river proximity analysis using buffer level of between 500 metres, 500 metres (7.50%) was classified as not suitable, 1000 metres (14.17%) was classified as less suitable, 1500 metres (19.17%) was classified as moderately suitable, and 2000 metres (25%) was classified as suitable while 2500 metres (34.17%) was classified as highly suitable due to its proximity to the crop land.

The road proximity analysis, using the spatial analysis tool Euclidian distance of road in ArcGIS 10.6, land far by road, they are classified as follows: Between 0-2 km (6.25%) was classified as highly suitable, 2-4 km (15%) was classified as suitable, 4-7km (22.5%) was classified as moderately suitable, 7-10 km (26.25%) was classified as less suitable and between 10-15km (30%) was classified as not suitable due to the distance from the crop land.

4. Conclusion

The suitability analysis in the study area shows that the soil in the study area is highly suitable for planting of sorghum. Similarly, Rice is moderately suitable in most part of Kaduna State with suitability value of around 2,285,255.79 (ha). The Maize cultivation is suitable in most part of the study area, although it is not suitable in the border town of Chikun Local Government Area and fringe part of Kachia with suitability value of 42,756.58 (ha). The statistical analysis of the generated data reveals that the areas are equally suitable for the production of the selected cereal crops.

References

Adebayo, A. A. (2000). Agro-climatic Classification of Adamawa State, Nigeria for Upland rice production. The Nigerian Geographical Journal, New series. Vol. 3 & 4, pp 83-97.

Ajetomobi, J., Abiodun, A., and Hassan, R. (2011). Impacts of Climate Change on Rice Agriculture in Nigeria. Trop. Subtrop. Agro. Syst. 14:613-622.

Angela, I. E and Fidelis, H. B. (2013). Effects of Climate Change on Rice Farming in Ardo Kola Combination and Ordered Weighted Averaging. Informatica 33(4):459-474

Ayoade, J. O. (2005). Introduction to Agroclimatology, Vintage, Publisher, Ibadan, Nigeria. Center for Soil Research (CSR)/ Food and Agricultural Organization (FAO) (1983).

Cellallos-Silva, and Lopez-Blanco, J. (2003) Delineation of suitable areas for crops using a Multi-criteria Evaluation Approach and Land Use/Cover Mapping: A case study in central Mexico. Agricultural System, 77,117-136

Fatih Sarı and Fatma Koyuncu Sari (2021) Multicriteria decision analysis to determine the suitability of agricultural crops for land consolidation areas. *International Journal of Engineering and Geosciences– 2021; 6(2); 64-73*

Getachew, T. A and Solomon, A. B. (2015) Land Suitability Analysis for Rice Production: A GIS Based Multi-Criteria Decision Approach. American Journal of Geographic Information System. Vol. 4(3): 95-104

IBM Corp. Released 2015. IBM SPSS Statistics for Windows, version 23.0 Armonk, NY. IBM C

Review on Depth Determination Bathymetry Using Remote Sensing Technique- Theoretical Appraisal

Adeleke, A.[1], Odumosu, J.[2], Baba, M.[1] & Bako. M.[1]

[1]Department of Surveying and Geoinformatics, Federal University of Technology, Minna

[2]Department of Surveying and Geoinformatics, Federal University Ekiti, Oye Ekiti.

Corresponding email address: Adelekeayobami06@gmail.com

Abstract

The determination of topography of the seabed using remote sensing technique is important in the study of oceanic/sea dynamics. This paper presents the bathymetric mapping technologies by means of satellite remote sensing (RS) with special emphasis on bathymetry derivation models, methods, accuracies. Bathymetric mapping by using echo sounding sounders could result to some constraint. However, Remote sensing (RS) technologies present efficient and cost-effective means of mapping bathymetry over remote and broad areas. RS of bathymetry can be categorized into two namely: Active and Passive RS. Active RS methods are based on active satellite sensors, which emit radiation independent of sunlight to study the earth surface or atmospheric features, e.g., light detection and ranging (LIDAR), altimeters, etc. Passive RS methods are based on passive satellite sensors, which detect sunlight (natural source of light) radiation to study earth surface e.g., multispectral or optical satellite sensors. The Stumpf's algorithm seems to perform better both in water attenuation and bottom reflectance having about 9.7% accuracy. This paper presents the development of bathymetric mapping technology by using RS, and to make most preferred preference models that can be used to determine seabed topography at a lower depth.

***Keyswords**: Bathymetric Survey, Signal Reflectance, Multispectral, Sentinel-1, Depth Extraction Algorithm.*

Introduction

For the purpose of safe navigation, marine science measures the physical characteristics of water bodies that dynamically fluctuate over time. These measurements include bathymetry as well as the shape and features of the shoreline, the characteristics of tides, currents, and waves, and the physical and chemical properties of the water (Jawak et al., 2013). Bathymetry survey measures depths to examine the topography of water bodies such as lakes, rivers, streams, and oceans (Gianinetto & Lechi, 2013). One of the foundational studies in the field of remote sensing (RS) of the maritime environment, which has many real-world applications to the coastal environment, is the measurement of bathymetry using satellite pictures.

Monitoring undersea topography, tracking the movement of deposited sediments, and creating maritime charts for navigation are just a few of the many applications that require accurate water depth determination. The management of port facilities, dredging activities, and the forecasting of channel filling and sediment budget all benefit from this knowledge (Bagheri et al., 1998). Many areas of oceanography, paleoclimate research, and marine geology depend heavily on bathymetric data. Making bathymetric maps using depth data is the process of bathymetric mapping. In a similar way to how topographic maps show the elevation of the Earth's surface at various geographic coordinates, bathymetric maps show the depth of a water body as a function of geographic coordinates (Jawak & Lius, 2014).

Lines of equal depths, or isobaths, are used to show the most common sort of bathymetric maps. To create nautical charts, shaded relief maps, and digital terrain/bathymetric models nowadays, bathymetry is mapped using echo sounders and the depth datasets are processed. Typically, nautical charts, 3D models, and seafloor profiles are produced using bathymetric data (Guenther et al., 2000). The time it takes a laser beam or an acoustic sonar pulse to travel from the water's surface to the ocean floor and back is how ocean floor data are often gathered. This time is dependent on the speed of sound in the water, sensor characteristics, time, and other factors. The numerous bathymetry acquisition systems differ in terms of spatial resolution, coverage, temporal resolution, and data type.

Remote sensing techniques have already been developed to map bathymetry. In essence, it can be divided into two groups. The first method relies on active remote sensing data (geodetic); the second uses passive sensors and multi-spectral data. Both active and passive data approaches are emphasized in this essay. The methods used to derive bathymetry can also be divided into imaging and non-imaging categories. The two main non-imaging methods utilized for bathymetry derivation are LIDAR and satellite altimetry. LIDAR, also known as light detection and ranging, uses a single wave pulse or two waves to estimate the distance between a sensor and an ocean floor or water surface (Wang & Philpot, 1998). The round tripe of the microwave pulse from the satellite to the water bodies and back to the satellite through the analysis window is what determines the distance between the water bodies and the satellite in contrast to the distance measured by satellite altimetry (Cazenave et al., 2002). The goal of this study is to demonstrate various bathymetry techniques employing both active and passive RS while validating which is best based on existing literature.

Method/Models of Deriving Bathymetric Using Remote Techniques

I. **Optical Remote Sensing-based bathymetry:** This is based on the idea that water depth affects the overall quantity of radioactive energy reflected from a water column (Huang et al., 2001). With its inclusion of shortwave radiation with strong penetrating properties in the blue and green spectra, optical RS has an advantage. Various amounts of energy are released and captured in RS images as the incoming radiation travels through the water and is dispersed and absorbed by water molecules and other in-water components. After accounting for atmospheric corrections and water column effects, the energy the sensor receives is inversely proportional to the water depth. Indicative of the depth at which solar radiation has penetrating power is the intensity of the signal that is returned (Alphers, & Hennings, 1984).

II. **Bathymetric measurement using Multi-spectral Imagery**: This method of determining depth is thought to be relatively unreliable, particularly near coastlines, lakes, shoals, and reefs (Vogelzang et al., 1989). some of the Earth's dynamic places with the most constant change. Bathymetry data from MS/HS imagery are not accurate enough to be used for navigation. However, a cost-effective solution for bathymetry across huge areas is a system based on MS/HS imaging. There are several environmental and scientific applications for these bathymetric products. Bathymetry obtained from imagery is estimated rather than directly measured, and as a result, has a lesser degree of precision than bathymetry derived from LIDAR or multi-beam echo sounders. The usefulness of the imaging at depth is constrained by light attenuation. Because of problems with light penetration, depths deduced from aerial or satellite photos are only accurate to 25 to 30 meters, depending on the quality of the water (Jawak & Lius 2015).

III. **Bathymetry Using Hyperspectral Scanner**: More spectral discrimination power may now be applied to the coastal optics problem because to the development of HS scanners, which sample the upwelling radiance spectrum in several tens of bands with strong water penetration (Calkoen et al., 1993). In comparison to multi-spectral approaches, HS methods make it easier to distinguish between many independent environmental variables. The complexity of HS imagery exceeds that of MS imagery. Bathymetry extraction from HS images is currently a work in progress.

The higher spectral band count utilized by HS sensors makes it possible to distinguish between various elements of the water column and sea bed. However, because to this added complexity, it can only be used for research applications (jawak & Lius 2012). In comparison to what is feasible with MS sensors, the additional spectral bands improve depth determination and allow for more precise measurement of water depth and bottom type. Since most HS imagery is still gathered via airborne acquisition techniques, it lacks the benefits of satellite imagery.

IV. **Bathymetry Using Synthetic Aperture Rader (SAR)**: Using variations in the water surface, it deduces depth. This enables SAR to determine sea depth in murky aquatic situations, which was not possible with traditional remote sensing methods. Based on SAR's capacity to measure changes in sea surface height and roughness, bathymetry can be determined (Allouis, et al., 2010). A brighter zone appears on the radar image as a result of the rougher water enhancing the radar backscatter. Knowing the tidal currents and the wind is necessary for practical SAR bathymetric measurement, as the wind's speed and direction affect the roughness modulation. The SAR imaging mechanism, according to Alphers, Hennings, and colleagues (1984), entails three steps:

1. The inflection of the surface flow speed is caused by the interface between (tidal) flow and bottom topography.
2. Surface wave spectrum deviations are caused by variations in surface flow velocity and can be predicted using the action balance equation.
3. Radar backscatter levels fluctuate due to fluctuations in the surface wave spectrum. Two-scale and initial iterations of the Bragg model it is possible to calculate the backscatter deviations using the Kirchhoff model. The advantage of SAR is that it is unaffected by cloud cover and atmospheric disturbances. Instead of producing absolute depths, it creates relative bathymetry. The method is especially well adapted to shoals and sandbanks where bathymetry is constantly changing. To determine ocean depth, SAR bathymetry readings are measured and modified, but this process has a number of intrinsic errors. Because to them, SAR-derived bathymetry is difficult to calculate and, when compared to other technologies, is intrinsically unreliable (Jawak & Lius 2014).

V. **Bathymetric Using Satellite Altimetry:** Globally, the oceans' gravity fields can be measured using satellite altimetry. To roughly determine the bathymetry of deep-seafloor features like seamounts and ridges, gravity field data can be used. When combined with data from other satellite missions, multi-satellite altimeter readings can be used to calculate the sea surface height at multiple georeferenced locations on the seafloor (Calmant, 1994). These maps can be useful for a variety of applications, such as finding barriers to the main ocean currents and shallow seamounts, despite their very low accuracy and resolution for assessing navigational risks. Plate boundaries and oceanic plateaus are also revealed by bathymetry determined from altimetry.

Models (Algorithm) For Deriving Bathymetric Survey Using Remote Sensing Technique

i. Stumpf's Model/Linear Ratio Model:

In order to circumvent the limitations of changing substrate albedo (a surface's reflecting power) when obtaining bathymetry data, Stumpf et al., 2003 created the "Ratio approach." The model, which is based on the idea that light dims exponentially with depth, suggests that the impacts of substrate albedo be reduced by employing two bands to calculate depth. Here is a mathematical explanation of this idea:

$$Z = g^{-1}\left[Ln(Ad - R_{\infty}) - Ln(R_w - R_{\infty})\right] \qquad 1$$

Ad is the bottom albedo, Z is depth, g is a function of the diffuse attenuation coefficients for both downwelling and upwelling light, R is the water column reflectance if the water were optically deep, and Rw is observed reflectance. Instead of using albedo as a variable in depth derivation, the ratio model solves the problem by comparing the attenuation of two spectral bands. Several spectral bands deteriorate at various rates. As a result, depth will affect the ratio between two spectral bands. The modification in the bottom albedo should affect both spectral bands equally, but the modification in attenuation with depth will be greater than the alteration attributable to bottom albedo so that the ratio between two bands should remain comparable over different substrates at the similar depth. This can be illustrated mathematically as follows:

$$Z = m_1 \frac{Ln(nR_w(\lambda_i))}{Ln(nR_w(\lambda_I))} \_\, m_0 \qquad 2$$

Rw is the observed reflectance, Z is depth, m1 is a constant that can be adjusted to scale the ratio to depth, n is a constant that ensures the ratio is always positive, and m0 is the offset at a depth of m0. To employ passive MS images to map shallow-water bathymetry, a number of significant challenges are addressed by the ratio transform method (Stumpf's et al., 2003).

- ✓ it does not require the removal of dark water pixels,
- ✓ the ratio transform method has fewer empirical coefficients required for the solution, which makes the method easier to use and more stable over broad geographic areas,
- ✓ the ratio method can be tuned using available reliable depth soundings.

ii. Jupp's Model or Depth of Penetration Zone (DOP) Model:

Jupp's depth of penetration zone (DOP) approach is a model that is frequently used in literature to rebuild the bathymetry in coastal zones using MS data. The Jupp technique consists of two components (Jupp, 1988):

a) The computation of DOP zones, and
b) The interpolation of depths within DOP zones.
c) This method has three fundamental assumptions:
d) a) Attenuation of light is an exponential function of depth,
e) b) Water quality does not vary within an image, and
f) c) Reflective properties of the substrate are constant.

The second and third assumptions are the model's weak points because, since a satellite image typically covers a very vast area, water and bottom parameters can occasionally shift. The relative loss of radiant flux when considering a group of monochromatic light is inversely correlated with the length of the path and exhibits a lower coefficient of proportionality (extinction coefficient). Jupp's model can be written mathematically as:

$$L_e = (e^{-2kz})L_b + (1 - e^{-2k})L_w \qquad 3$$

where Le is measured at-sensor radiance, Lb is the emergent radiance from the seabed, Lw is the emergent radiance from different layers of water, z is depth, k is the coefficient of absorption. If the term Lw is hypothesized as negligible and is directly related to the quality of the water (suspended sediments) and small changes in the seabed, then, among the depth of the water column and the logarithm of the measured at-sensor radiance, there will be a linear relationship. Under these conditions, rearranging Equation (3) lead to the classical DOP equation for the water depth determination:

$$Z = \sum_{i-j}^{N} ln \frac{(L_e)i}{-2k_{tN}} - \sum_{i-j}^{N} ln \frac{(L_b)i}{-2K_{tN}} \qquad 4$$

where N represents how many spectral bands there are. In reality, the DOP model expects a constant coefficient of absorption to ensure homogeneity, which is the fundamental reason why the DOP algorithm fails in some situations when the geographical lack of homogeneity is very large (jupp, 1988).

iii. The Stratified Genetic Algorithm (SGA): is a development of the Depth of Precision (DOP) model proposed by Jupp (1988) that states:

$$Z = \sum_{i-1}^{N} \frac{\ln(L_e)}{-2K_iN} - \sum_{i-1}^{N} \frac{\ln(L_b)i}{-2k_iN} \qquad 5$$

Le is measured radiance at the sensor, Lb is radiance from the seabed, k is the absorption coefficient of the water and N is the number of spectral bands. The second term is removed and replaced with a regression coefficient (Yj) to give:

$$Z = \sum_{J-1}^{m} \frac{\ln(L_e)j - Yj}{-2Kj} \qquad 6$$

where m is the number of layers. The SGA method divides the water column into levels of increasing depth and computes kj and Yj for each in order to calculate water depth. This algorithm is repeated for all spectral wavebands and those with a high correlation Coefficient is used to determine depth.

iv. **Wave Tracing Method:** Fast Fourier transformation (FFT) is a technique used to decompose a function in spatial domain into its constituent frequency components. It can be very useful while obtaining regular periodicity in the images (Baban, 1993). FFT can also be used for retrieving the wavelength and wave direction of the ocean surface waves. The FFT of a SAR sub image of N × N pixel size gives a 2-D image spectrum. The peak in this spectrum represents the mean wavelength and the mean wave direction. The wavelength and angle of propagation can be estimated using:

$$L = \frac{N\Delta X}{\sqrt{U^2 + V^2}} \quad 7$$

$$\theta = \arctan\frac{u}{v} \quad 8$$

where L is the measured peak wavelength, θ is the peak wave direction, Δx is the spatial resolution of the subset image, N is the size of the sub-image, and u and v are the coordinates of the dominant frequency with the centre point as origin.

v. **Lyzenga Model or Linear Band Model:** The amount of light reflected, which is influenced by the atmosphere, water clarity, depth attenuation, bottom reflectance, scattered suspended particles, and other factors, is what is measured by satellite RS data. Campbell described how the penetrability, bottom reflectance, and suspended material scattering of the solar spectrum vary. Thus, the RS data can be categorized using multiband radiance to improve the accuracy of water-depth estimation. Under ideal circumstances, the sea depth can be obtained from a satellite given the assumptions of a homogeneous atmosphere, identical wave situation, similar water property, and homogeneous bottom property. The satellite sensor measures the visible light reflected from the bottom after entering the water column. Beer's Law states that light attenuates exponentially with depth in the water column, and the following could be said of the connection between measured reflectance and depth:

$$R = (A_b - R_\infty)exp(-gz) + R_\infty \quad 9$$

where R∞ is the water column reflectance, if the water is optically deep, Ab is the bottom albedo, z is the depth, and g is a function of the diffuse attenuation coefficients for both down-welling and up-welling light. However, the derivation of depth from a single band is dependent on the albedo Ab, with a decline in albedo resulting in amplification in the estimated depth. Lyzenga proposed a linear solution of correction for albedo with two bands as;

$$Z = a_0 + a_{1xi} + a_{2xj} \quad 10$$

where $X_1 = ln[R\lambda_i - R_\infty(\lambda_i)]$ and λ is the wavelength. The algorithm corrects for a range of variations in both water attenuation and bottom reflectance using a linear combination of the log-transformed radiances in the blue and green channels. Lyzenga model has essentially attempted to account for unpredictability in bottom type by using multiple spectral bands. A variable, Xj, was defined for each of the N bands as:

$$X_j = ln\left(L_j - L_{wj}\right) \quad 11$$

where, Lj = above-surface reflectance in band j and Lwj = averaged deep-water reflectance. The reflectance values were log transformed to create a linear relationship between input reflectance and depth. Deep-water reflectance was used to account for reflection because of surface effects and volume scattering in the water column and was assumed to result mostly from external water reflection, including sun-glint effects, and atmospheric scattering. However, the effect of deep-water radiance was almost negligible in shallow water bodies. To account for water quality heterogeneity and depth-independent variability in reflectance values between bands this algorithm was updated by Lyzenga et al., (1998).

Conclusion

Due to the advancement of technology applications such the utilization of acoustics, optics, and radar, bathymetry derivation technology has advanced significantly over the past century. To validate RS based models for the derivation of bathymetry in distant areas of the earth, more acoustic depth soundings are needed. However, the current review largely focuses on the many methods and technologies developed for bathymetric derivation, as well as the benefits of various bathymetric algorithms. RS approaches for bathymetry derivation can be divided into two categories: active RS/passive RS and non-imaging/imaging.

Due to technical limitations, the non-imaging LIDAR approach is not frequently employed for practical applications even though it is capable of accurately detecting elevations at sampled locations. In clean open waters, the LIDAR approach can calculate depths up to 65 m with an accuracy of 15 cm (Shridhar et al., 2015). Bathymetric mapping over relatively limited geographic areas is suited for airborne LIDAR. Turbidity in the water also limits LIDAR accuracy and application. The passive optical imaging method, in contrast, offers greater flexibility because it can be applied either analytically or empirically.

Since analytical modeling calls for the input of in-situ observed quantities linked to the optical characteristics of water, its implementation is complicated. As empirical modeling just needs a small number of in-situ measurements at certain sample locations, it is significantly simpler to apply. Under some conditions, this implementation may yield results with an accuracy comparable to that of analytical or semi-analytical implementations. Both broad oceanic waters and shallow, turbid coastal seas are amenable to the passive imaging techniques. For an efficient bathymetric derivation, choosing the best bathymetric algorithm is just as crucial as choosing the best image sensors. Each used model or sensor has strengths and weaknesses. The majority of the case studies have made use of optical data from satellites like Quick Bird, SPOT, Landsat, and IKONOS. In general, the Lyzenga model (linear band model) used for Quick Bird data can produce a sea depth error of roughly 9.7%, whereas the RMS for IKONOS is 2.3 m. Using a linear combination of the log-transformed radiances in the blue and green spectral channels, the Lyzenga method adjusts for a variety of variations in both water attenuation and bottom reflectance.

Less than 25 meters of water can have depths retrieved using the Stumpf's model or ratio transform model. In comparison to the linear band model, it also performs better when scattering turbidity (St In water depths between 15 and 20 meters, the ratio model is found to be slightly less noisier and can always resolve fine morphology properly. In general, it was discovered that the ratio transform was less reliable than the linear transform. Jupp's, Stumpf, and Lyzenga models were occasionally utilized when depths of less than 30 m were discovered using various approaches. Based on in-situ data, the empirical model (SPOT-5 imaging) may produce an accuracy of 0.5m. The stumpf's model outperforms the lyzenga and jupp models in terms of precision and test stability in shallow seas, where empirical fitting is time-efficient but requires real-time high-density depth soundings to get precise results. sumpf et al. 2003).

Bathymetry derivation accuracy was generally found to be depth dependent, with more mistakes being shown at deeper depths and fewer errors occurring at shallower depths. In general, optical RS models used for mapping the bathymetry have a number of advantages as well as some drawbacks. With adequately representative training data sets, two of the algorithms—Linear/Lyzenga and Ratio/Stumpf—are found to be more effective in determining the shallow depth in severely turbid seas.

Because the ratio transform approach or Stumpf model uses fewer empirical coefficients, it is easier to employ and more reliable across a wider range of geographic areas. In a non-homogeneous setting, the ratio model is more reliable. In comparison to the linear transform, the ratio transform has drawbacks, especially when there is more noise present. The Lyzenga linear band model, on the other hand, uses two or more bands, allowing for the separation of depth variations from bottom albedo variations while compensating for turbidity. When compared to stumpf's model, retrieval of bathymetry data under constrained environmental conditions is constrained.

Reference

Allouis, T., Bailly, J.S. & Feurer, D. (2010)., Assessing Water Surface Effects on LiDAR Bathymetry Measurements in Very Shallow Rivers: A Theoretical Study. 2nd ESA Space for Hydrology Workshop, Geneva, 12-14 November 2007, 12-14.

Alphers, W. & Hennings, L. (1984) A Theory of the Imaging Mechanism of Underwater Bottom Topography by Real and Synthetic Aperture Radar. Journal of Geophysical Research, 89, 10529-10546.

Baban, S.M.J. (1993) The Evaluation of Different Algorithms for Bathymetric Charting of Lakes Using Landsat Imagery. International Journal of Remote Sensing, 14, 2263-2273. http://dx.doi.org/10.1080/01431169308954035

Bagheri, S., Stein, M. & Dios, R. (1998) Utility of Hyperspectral Data for Bathymetric Mapping in a Turbid Estuary. International Journal of Remote Sensing, 19, 1179-1188. http://dx.doi.org/10.1080/014311698215676

Calkoen, C.J., Kooi, M.W.A, Hesselmans, G.H.F.M. & Wensink, G.J. (1993) The Imaging of Sea Bottom Topography with Polarmetric P-, L-, and C-Band SAR. Report BCRS Project 2.1/AO-02, Netherlands Remote Sensing Board, Delft.

Calmant, S. (1994) Seamount Topography by Least-Squares Inversion of Altimetric Geoid Heights and Shipborne Profiles of Bathymetry and /or Gravity Anomalies. Geophysical Journal International, 119, 428-452

Cazenave, G.T., Dixon, T.H., Naraghi, M., McNutt, M.K. & Smith, S.M. (2002) Bathymetric Prediction from Seasat Altimeter Data. Journal of Geophysical Research, 88, 1563-1571. http://dx.doi.org/10.1029/jc088ic03p01563

Gianinetto, M. & Lechi, G. (2013) A DNA Algorithm for the Batimetric Mapping in the Lagoon of Venice Using Quick Bird Multispectral Data. XXth ISPRS Congress on Geo-Imagery Bridging Continents, The International Archive of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XXXV(B), 94-99.

Guenther, G.C., Brooks, M.W. & Larocque, P.E. (2000) New Capabilities of the "SHOALS" Airborne Lidar Bathymeter. Remote Sensing of Environment, 73, 247-55. http://dx.doi.org/10.1016/S0034-4257(00)00099-7

Huang, W.G., Fu, B., Zhou, C.B., Yang, J.S., Shi, A.Q. & Li, D.L. (2001) Shallow Water Bathymetric Surveys by Spaceborne Synthetic Aperture Radar. IEEE International Geoscience and Remote Sensing Symposium, Vol. 6, Sydney, 9-13 July 2001, 2810-2812. http://dx.doi.org/10.1109/igarss.2001.978171

Jawak, S.D. & Luis, A.J. (2012) Synergistic Use of Multitemporal RAMP, ICESat and GPS to Construct an Accurate DEM of the Larsemann Hills Region, Antarctica. Advances in Space Research, 50, 457-470. http://dx.doi.org/10.1016/j.asr.2012.05.004

Jawak, S.D. & Luis, A.J. (2013) A Comprehensive Evaluation of PAN-Sharpening Algorithms Coupled with Resampling Methods for Image Synthesis of Very High Resolution Remotely Sensed Satellite Data. Advances in Remote Sensing, 2, 332-344. http://dx.doi.org/10.4236/ars.2013.24036

Jawak, S.D. & Luis, A.J. (2014) A Semiautomatic Extraction of Antarctic Lake Features Using WorldView-2 Imagery. Photogrammetric Engineering & Remote Sensing, 80, 939-952. http://dx.doi.org/10.14358/PERS.80.10.939

Jawak, S.D. & Luis, A.J. (2015) Spectral Information Analysis for the Semiautomatic Derivation of Shallow Lake Bathymetry Using High-Resolution Multispectral Imagery: A Case Study of Antarctic Coastal Oasis. International Conference on Water Resources, Coastal and Ocean Engineering (ICWRCOE 2015), Aquatic Procedia, 4, 1331-1338. http://dx.doi.org/10.1016/j.aqpro.2015.02.173

Jawak, S.D., Luis, A.J., Panditrao, S.N., Khopkar, P.S. & Jadhav, P.S. (2013) Advancement in Landcover Classification Using Very High Resolution Remotely Sensed 8-Band WorldView-2 Satellite Data. International Journal of Earth Sciences and Engineering, 6, 1742-1749.

Jupp, D.L.B. (1988) Background and Extensions to Depth of Penetration (DOP) Mapping in Shallow Coastal Waters. Proceedings of the Symposium on Remote Sensing of the Coastal Zone, Gold Coast, IV2(1)-IV2(19).

Lyzenga, D.R. (1978) Passive Remote Sensing Techniques for Mapping Water Depth and Bottom Features. Applied Optics, 17, 379-383. http://dx.doi.org/10.1364/AO.17.000379

Stumpf, R.P., Holderied K. & Sinclair, M. (2003) Determination of Water Depth with High Resolution Satellite Imagery over Variable Bottom Types. Limnology and Oceanography, 48, 547-556. http://dx.doi.org/10.4319/lo.2003.48.1_part_2.0547

Vogelzang, J., Wensink, G.J., De Loor, G.P., Peters, H.C., Pouwels, H. & Gein, W.A. (1989) Sea Bottom Topography with X Band SLAR. BCRS Report, BCRS-89-25.

Vogt, P.R. & Jung, W.Y. (1991) Satellite Radar Altimetry Aids Seafloor Mapping. EOS Transactions, American Geophysical Union, 72, 465-469.

Wang, C.-K. & Philpot, W.D. (2007) Using Airborne Bathymetric Lidar to Detect Bottom Type Variation in Shallow Waters. Remote Sensing of Environment, 106,123-35. http://dx.doi.org/10.1016/j.rse.2006.08.003

Assessment of the Hydrological Characteristics of Shiroro Dam, Nigeria

Adesina E.A.[1a], Musa A.[1b], Onuigbo, I.C.[1b], and Adesiji, A. R.[2]
[1]Department of Surveying & Geoinformatics, Federal University of Technology, Minna
[2]Departemt of Civil Engineering, Federal University of Technology, Minna
[a]adegeoworldsolutions@gmail.com; [b]ahmed.musa@futminna.edu.ng; [c]anyi.onuigbo@futminna.edu.ng;
Correspondence email: **adegeoworldsolutions@gmail.com**

Abstract

Flooding in recent times has been linked to various hydrological characteristics that are associated with dams and their surrounding features, some of which are outflow, inflow, rainfall, temperature, and water elevation, among others. Although its causes have been traced to both natural and human-induced factors, it is also important to investigate the various hydrological characteristics of dams to understand and manage flooding. The relationship between these features has a great effect on the amount of outflow, which in turn relates to the flooding of communities downstream. This study seeks to assess and analyse the impact of inflow, rainfall, temperature, and water level on the outflow of water from the dam. This impact was evaluated using statistical techniques such as time series, correlation, and regression analysis. The result shows that outflow in dams has a positive correlation of 0.280738, 0.873933, 0.148858, and 0.55576 with rainfall, inflow, temperature, and water elevation, respectively. Water inflow and elevation thus have a greater influence on water outflow; R2 values show that inflow can predict 76.4% of the volume of outflow while temperature has the lowest value of 0.22%. More study of the factors that influence inflows has been recommended, as has the forecast of future outflows and output.

Keywords: Shiroro Dam, hydrological parameters, seasonality, trend, regression, and forecasting

1 Introduction

Flooding has been one of the major disasters ravaging lives and properties in recent years. It has been linked to various factors such as climate, man-induced disasters, and other factors. Features along the river course or floodplain are the major victims of the flood disaster (Gangrade *et al.*, 2019). Bilewu (2017) stated that there will be an increase in the frequency and intensity of flood events along this course in the coming years. The frequency of which was observed in the recent flooding events in Nigeria that drew international attention. It is therefore important to investigate the causes, effects, and management of flooding.

Hydrologically related infrastructure has also been one of the major sources of flooding. One of these infrastructures is the dam, which is the artificial catchment of water that is either for irrigation, fishing, water supply, or hydroelectric power supply purposes (Adie *et al.*, 2012). The dam as an infrastructure has served its purpose over the years but has also been one of the major sources of flood-related disasters.

One of the usual practises in flood management is outflow activities; the dam is often opened through the spillway to reduce the volume of water downstream. Several factors have influenced the volume of outflow, varying from temperature, inflow, and water elevation to other factors (Sivongacy *et al.*, 2017). Heavy rain, coupled with the rapidly increasing need for housing, frail implementation of building regulations, poor drainage systems, and choked waterways, cause rainwater to be diverted through populated areas, where it devastates communities. It is also common that, to forestall dam collapse at peaks of rainfall, authorities in Nigeria and in neighbouring countries like Cameroon open the spillways of the dam and release vast amounts of water into communities on the dams' floodplains. The human and material costs of such releases of water by the dam authorities and the resultant inundation of the dam's floodplain are enormous, but they are often either not reported at all or underreported (Olukanmi and Salmai, *et al.*, 2012).

On the other hand, in Nigeria alone, it is estimated that approximately 12% of the land area is within the 100-year floodplain (Sharma, 2017). The percentage of urban and rural areas within the floodplain is much higher (about 20%). The total property value within the floodplain already exceeds hundreds of millions of Naira and is growing at a rate of about 5% per annum. Flood disasters have increased tremendously everywhere in Nigeria in recent times, resulting in the loss of lives and properties, rendering thousands homeless, and disrupting economic activities.

Thus, the ability to simulate the propagation of flood waves is of crucial importance for the planning and operational management of river floods. Hydrodynamic and hydrologic numerical models provide such capabilities and represent conventional approaches to river flood modelling. Hence, without flood control and adequate drainage structures, the extent of destruction and damage would increase at an even faster pace. There were over 200 floods affecting over 180 million people, 8,000 deaths, and over £40 billion in damages in 2007 (Pitt, 2007).

Historically, many towns have been built on floodplains, and this is for a number of reasons, which include: access to fresh water; the fertility of floodplain land for farming; cheap transportation via rivers and railroads, which often followed rivers; the ease of development of flat land; and these towns are highly susceptible to flooding (Orukpe and Mohammed, 2015). However, the risk is greater for those living on the floodplain of the country's major rivers and its many dams, which are used for hydropower generation, irrigation, and fish farming. Many of the dams are poorly designed and maintained and are located close to towns and villages. During the rainy season, they can burst their banks, releasing deluges of water into neighbouring communities. It is also common that, to forestall dam collapse at peaks of rainfall, dam authorities in Nigeria, like those at Shiroro dam in Niger State and Oyan dam in Ogun State, open the spillways of the dam and release vast amounts of water into communities on the dams' floodplains, sometimes some kilometres away from the water's release point. It causes severe flooding, affecting farmlands, human life, and property settling on the river bank.

According to the National Emergency Management Agency (2018), in 2017, floods affected 250,000 people in the eastern and central regions; in 2016, 92,000 people were displaced and 38 died; in 2015, more than 100,000 people were displaced, with 53 deaths; and in 2012, devastating flooding forced two million Nigerians from their homes and 363 died. If the extent and potential levels of damage are known, perhaps a strategy that reduces losses and suffering downstream could be adopted. Thus, if the impact of flooding is to be reduced in the future due to its significant impact downstream, it is important to evaluate the potential of dam flooding. This will assist in analysing downstream human safety, especially where no dam flooding or prolonged flooding histories are documented (Song *et al.*, 2012). It therefore becomes necessary to effectively estimate and forecast flooding so as to prevent its ill-effects.

The hydrological implications of future climate change will likely require important changes to present-day water management policies (Sovacool and Bulan, 2012), with alteration of dam operations featuring prominently (Tang *et al.*, 2018). However, while much work has been documented on the potential impacts of climate change on operations at individual reservoir facilities (Vassoney *et al.*, 2012) or even in the context of tributary basins (Zeng, 2017), the impact of an entire population of reservoirs at a regional scale (i.e., across the entire regional network of rivers) has yet to be established.

The magnitude of the 2010, 2012, 2015, 2018, and 2019 floods caused by the opening of Shiroro dam spillways by the dam authority, the extent of damages, and the fact that absolute safety against flooding cannot be guaranteed make it imperative to carry out an in-depth study of the affected reaches of the Shiroro dam floodplain.

Since frequent release of the dam reservoir due to excessive rainfall is an identified cause of flooding within floodplains, this study presents an analysis of various hydrological characteristics (rainfall, temperature, inflow, and water elevation) of the Shiroro dam and its environs with a view to understanding its hydrological dynamics and correlating the same with past flood events within the study area. The outcome of this study will serve as a viable tool for determining hydrological considerations.

2 The Study Area

The Shiroro hydropower plant is located approximately southwest of the Kaduna River and was commissioned in 1990 with a capacity of 600 MW. It is located 550.325 m downstream of the confluence of the Kaduna River with its tributaries. The dam is geographically located between longitude 6º 20'00″E and 6º 50'00″E and latitude 9º 50'00″N and 10º 10'00″N. The dam is of rock type and stands 115 m above the original riverbed elevation across Shiroro Gorge for a crest length of 700 m. Shiroro hydropower plant has a surface area of about 320 km^2, a maximum length of 32 m, and a total storage capacity of 7 billion m^3 (Suleiman and Ifabiyi, 2015).

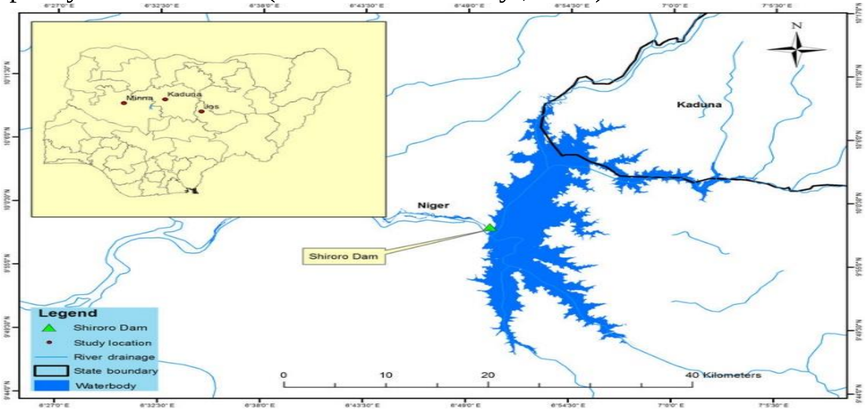


Figure 1: The study area Map

3 Materials and methods

This study adopted the quantitative research design and relied mostly on secondary data sourced from the dam authority.

Data on the hydrological characteristics of the dam were acquired over a period of 20 years at 5-year intervals, i.e., 2001, 2005, 2010, 2015, and 2020. The summary of the data used for the study is given in Table 1.

Table 1: Data used for the study

S/N	Data	Method of observation/collection	Duration
1	Rainfall	Automatic rain gauge	2001-2020
2	Inflow	Computed from record	2001-2020
3	Reservoir Elevation	Gauge from the dam	2001-2020
4	Temperature	Reading thermometer	2001-2020
5	Water outflow	Computed from record	2001-2020

Source: Shiroro dam authority, 2020

The average monthly value of the five-epoch data on each of the five hydrological parameters was generated.

The analysis helps establish a mathematical and statistical relationship between the independent hydrological variables (rainfall, temperature, water elevation, and inflow) and the dependent variable (outflow). Correlation analysis was carried out to investigate whether there is a positive or negative relationship between the dependent and independent variables.

3.1 Forecasted outflow data

There are several time series processes for analyzing and forecasting seasonal data, they are white noise, Auto Regressive Model, and Moving Average Model among others (Ivanosvski *et al.*, 2018). The Auto-Regressive Model is the one in which Y_t mathematically depend on its past value $Y_{t-1,}, Y_{t-2}, Y_{t-3}$ and it is mathematically represented as,

$$Y_t = f\{ Y_{t-1,}, Y_{t-2}, Y_{t-3}, \dots \in_t \} \quad (1)$$

While the Auto Regressive Model for a dependent model, say p past values is given as,

$$Y_t = \beta_0 + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \beta_3 Y_{t-3} + \dots + \beta_3 \quad Y_{t-p} + \in_t \quad (2)$$

The moving average model when Y_t mathematically depend on random error is mathematically represented as,

$$Y_t = f\{ \in_t, \in_{t-1,}, \in_{t-2}, \in_{t-3}, \dots \in_{t-n} \} \quad (3)$$

While the moving average model for a dependent model, say q past values is given as,

$$Y_t = \beta_0 + \in_t + \phi \in_{t-1} + \phi \in_{t-2} + \phi \in_{t-3}, \dots + + \phi_q \in_{t-n}$$

where Y_t represent the dependent variable (Outflow), $\in_t$ represent the seasonality index for each season, ϕ_q represents the past data and values for the independent variables, in this case is the Inflow data.
The Standard Centered Moving Approach (Standard CMA) was adopted in the list of seasonal index forecasting approaches because the analysis of residuals showed that the distribution could follow a linear regression approach. The Standard CMA was adopted because it is suitable for a linear distribution. Another approach to forecasting seasonality is the log-CMA approach, which is more suitable for non-linear variables.
Thus, the seasonalized index generated from this analysis was used to generate the forecasted outflow data for a duration of 5 years (2025, 2030, and 2035).
The regression analysis also helps measure how much of the dependent (outflow) is predicted by the independent variables. This information was then used to draw conclusions and make decisions about outflow and its relationship to flooding.

4 Results and Discussion

The results of the analysis include charts showing the average distribution of the hydrological characteristics over the years for a period of 20 years with 5-year intervals for data acquisition.

4.1 Time series analysis

The time-series description of the average rainfall is shown in Figure 2. Analysis of rainfall shows that the average dry season for the region is between November and March, except for an exceptional case in March 2015, where there was over 50 mm of rainfall.

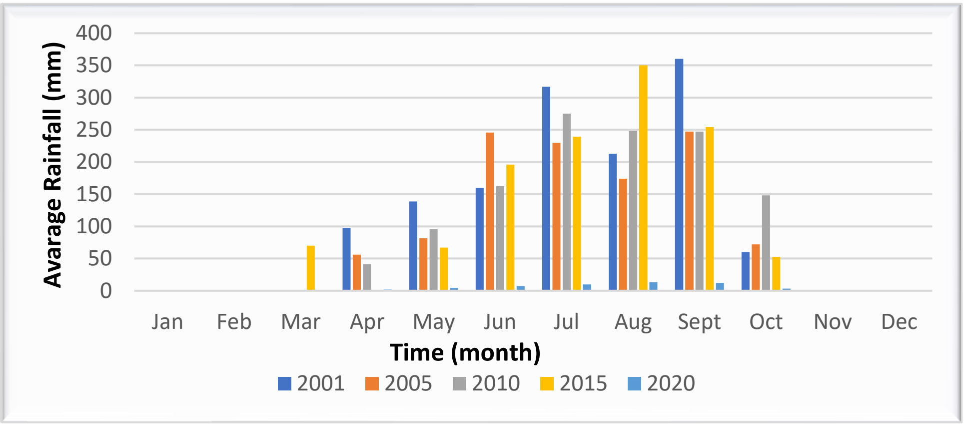


Figure 2: Average rainfall between 2001 to 2020

The rainy season lasts, on average, from April to October. This may be an indication of the period when outflow is high. The maximum rainfall is about 360 mm around September 2001, and the least is 0 mm.

Figure 3 depicts a time series analysis of the inflow, which shows that the inflow is generally low between November and April each year, with the average highest inflow occurring in September over the years. The inflow visually correlates with the rainfall chart; the maximum inflow is approximately 2,366 mm around September 2020, and the least is approximately 9.20 mm in April 2015. Between May and September, the inflow pattern gradually increases, peaking at that time before declining.

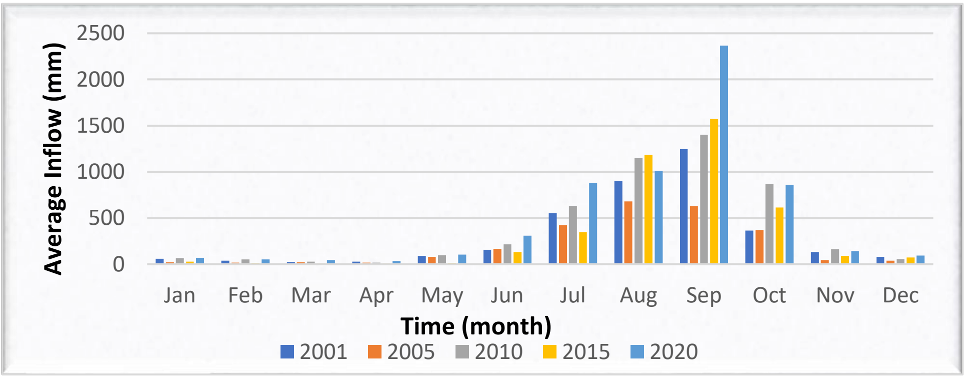


Figure 3: Average inflow between 2001 to 2020

The time series analysis of temperature in the study area reveals a temperature range of 20°C to 35°C between January and July of the year and an average range of 25°C to 30°C. The temperature seems to increase on average over the years, as observed in 2020 in Figure 4. The maximum temperature across the year is 39.45°C in October 2020, and the minimum is 21.52°C in January 2015.

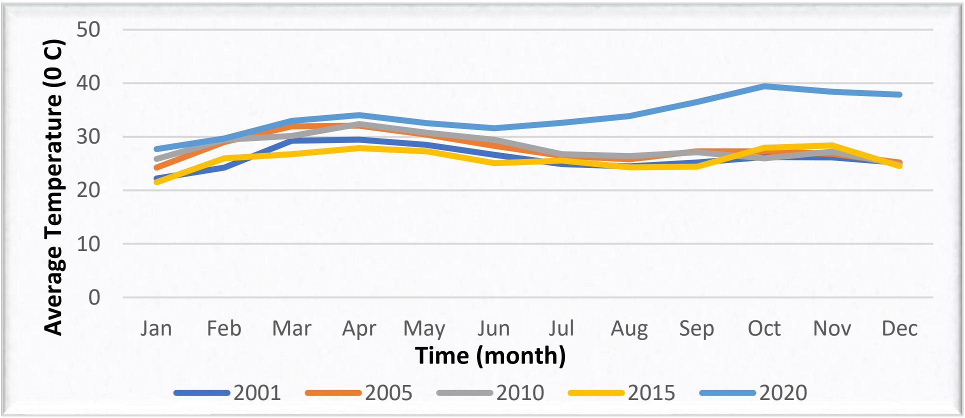


Figure 4: Average temperature between 2001 to 2020

The time series analysis of water elevation, as shown in figure 5, shows that the minimum water elevation in the study area is experienced around May to July and the highest range of water elevation is around September, October, November, and December, respectively. The highest water elevation observed over the years is 382.51 m in October 2020, and the least is 353.19 m in August 2005. The elevation of water also has a significant relationship with the outflow of water, as seen on the chart.

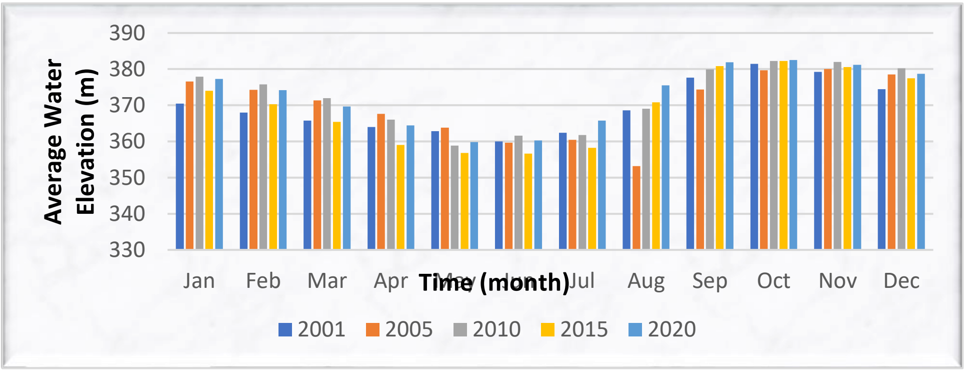


Figure 5: Average water elevation between 2001 and 2020

The time series analysis of the outflow of water, as seen in figure 6, showed the distribution of outflow across the years. It was discovered that the outflow increases from July to September and then gradually decreases until December of each year. The highest volume of outflow is 2214.95 mm in September 2020, and the least is experienced in May 2015 (-26.69 mm). The months with the highest range of outflows are periods where flooding incidents are mostly recorded in the settlement downstream.

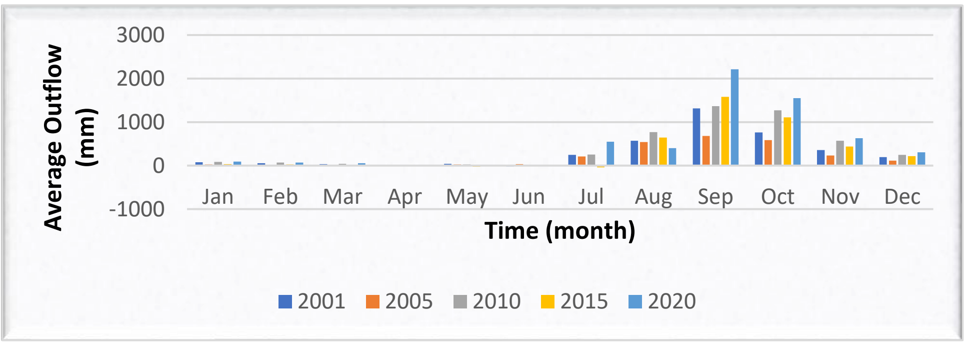


Figure 6: Average Outflow between 2001 and 2020

4.2 Correlation and regression analysis

The correlation and regression analyses are shown in Table 2. The correlation analysis between outflow and rainfall reveals a weak positive correlation of 0.280738, which is the second-lowest among other hydrological characteristics. The R-squared statistic shows that rainfall only predicts about 7.8% of the outflow incidents. The correlation analysis between inflow and outflow indicates a near-perfectly strong positive correlation of 0.873933, and the R squared values show that 76.4% of the outflow is predicted by the inflow. This is a strong statistical indication of the effect of inflow on outflow. The inflow also has the lowest standard deviation when compared to others. Similarly, a weak positive correlation of 0.148858 exists between temperature and outflow, indicating that, while temperature has a direct effect on outflow, it does not have a strong relationship in influencing the volume of outflow. This is supported by a very low R squared value of 0.0022159, which means temperature is only able to predict 0.22% of the volume of outflow. The correlation analysis shows a positive correlation of 0.55576 between the water elevation and the outflow of water, and the R square values show that the water elevation is able to predict about 30.89% of the volume of outflow in the dam. This shows that aside from inflow, water elevation is the next factor that influences the outflow of water in the study area. It also has the next-lowest standard deviation, as seen in Table 2.

Table 2: Correlation and regression analysis

Outflow (Y)	**Rainfall (X)**	**Temperature (X)**	**Inflow (X)**	**Water Elevation (X)**
Correlation	0.280738	0.148858	0.873933	0.55576
R Square	0.078814	0.0022159	0.763759	0.308887
Standard error	473.179	487.5128	238.4201	409.8513
Equation of line	Y= 1.262497*X +241.5391	Y= 18.77499*X - 186.464	Y= 0.869544*X + 48.66686	Y= 32.12798*X -11566

The forecasted volume outflow from 2025 to 2035 at 5-year intervals is shown in Table 3, while Fig 8 depicts the plot of the predicted and observed outflow.

Table 3: Forecasted Outflow data for 2025, 2030 and 2035

Forecasted/ Outflow	**2025**	**2030**	**2035**
Month	**m/s^3**	**m/s^3**	**m/s^3**
Jan	84.03105	88.84043	93.64981
Feb	63.67316	67.3001	70.92703
Mar	45.33419	47.9043	50.47442
Apr	5.521139	5.832675	6.14421
May	12.59561	13.30301	14.0104
Jun	23.76461	25.09306	26.42151
Jul	275.0542	290.3585	305.6629
Aug	749.189	790.6823	832.1756
Sep	1642.93	1733.504	1824.079
Oct	1285.324	1355.859	1426.395
Nov	521.0542	549.5183	577.9824
Dec	259.1367	273.2287	287.3206

As seen in Figure 8, the model adopted approximately fits with the existing data for outflow and could thus be adopted to make a decision; this is also confirmed by the residual analysis, which is approximately distributed as zero.

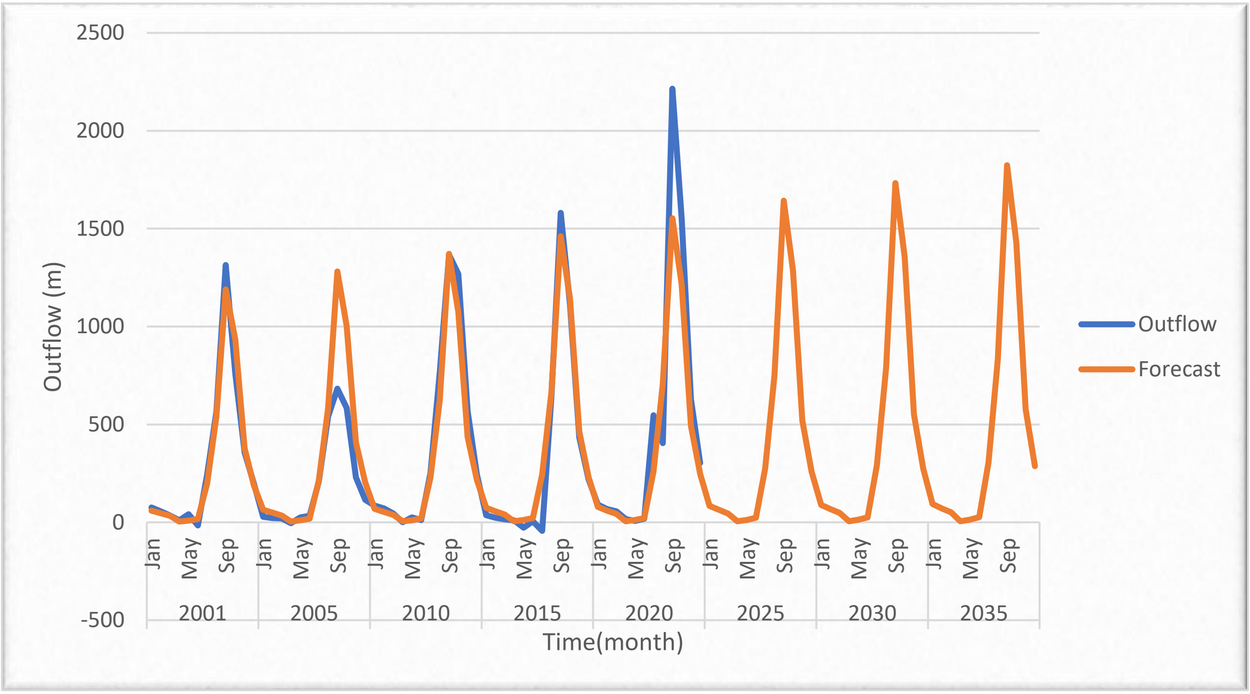


Figure 8: Previous and Forecasted (for 2025, 2030, and 2035) Outflow at the dam

The residuals plot for the forecasted and actual outflow values shows a reasonable spread around zero, which justifies the use of the model adopted in the study, as seen in Figure 9.

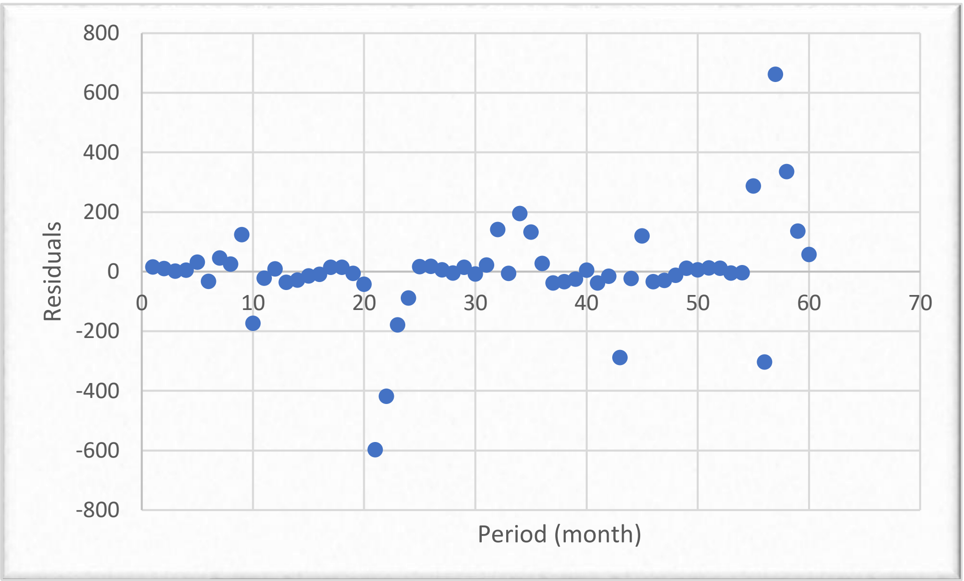


Figure 9: The residual plots for Outflow and Forecasted value

The time series and correlation analysis for rainfall show that rainfall does not really have the greatest impact on the outflow of water at the dam; the statistical analysis reveals a weak contribution to the overall flooding in the area. If the outflow is well predicted by the inflow, then it is important to investigate what the possible factors are that cause the inflow to rise. According to the analysis, temperature has the least impact on outflow; thus, inflow does not appear to have a large influence on the volume of outflow. The elevation of the water is the next factor after the inflow that has a greater influence on the volume of outflow, as seen in the analysis. The months with the highest volume of outflow also coincide with reported flooding incidents in the study area. This is proof that outflow has a greater influence on the flooding incidents experienced in the region.

5 Conclusion

Time series modelling and forecasting have fundamental importance for various practical domains, having in mind that time series forecasting enables predicting the future by understanding the past. Several factors may lead to flooding in relation to a dam and its features; the outflow from a dam, whether through release from a spillway or accidents relating to dam failure, has a greater effect on the settlements that are located downstream. The records of flooding incidents have increased over the years, and a proper study must be carried out to investigate the cause and a possible management approach. Four different factors were assessed in this study: rainfall, temperature, inflow, and water elevation, and the obtained result showed that inflow is the factor with the greatest influence on the volume of outflow, while other factors in decreasing order of their influence are water elevation, rainfall, and temperature, respectively. Since inflow is a major factor that influences outflow, the study thus recommends further study of inflow and the factors that influence its increase. Accuracy checks can also be carried out on the forecasted data to check the accuracy of this analysis and its recommendation.

Reference

Adie D. B., Ismail A., Muhammad M.M. and Aliyu U. B. (2012) Analysis of the water resources Potential and Useful Life of the Shiroro Dam, Nigeria. *Journal of Basic and Applied Science* 20(4)*:*341-349

Bilewu S. O., Aanshola A. M. and Salami A. W. (2017) A rapid health impact assessment of the University of Ilorin Dam *Nigeria Journal of Technology* 36(1): 235-240

Chaia G. T., Ma'arof M. I., and Sharma R. (2019) Trends in an increased dependence towards hydropower energy utilization- A short review *Cogent Engineering* 6(1): 1-14

Gangrade, S., Kao, S.C., Dullo, T. T., Kalyanapu, A. J., & Preston, B. L. (2019). Ensemble-based flood vulnerability assessment for probable maximum flood in a changing environment. *Journal of Hydrology* 576, 342–355.

Olukanni D. O. and Salami A. (2012) Assessment of Impact of Hydropower Dams Reservoir Outflows on the Downstream River Flood regime: Nigeria's Experience *Hydropower- Practice and application* DOI:10.5772/33180

Orukpe, P.E. and Mohammed, A.O. (2015) Fussy Control Technique Applied to Modified Mathematical Model for Malaria Control Nigerian *Journal of Technology* 34(4): 815-821

Sharma, R. H., & Awal, R. (2013). "Hydropower development in Nepal Renewable and Sustainable *Energy Reviews* 21, 684–693. doi: 10.1016/j.rser.2013.01.013.

Shiroro hydro-electric Power Station (2010). Hydrology, Meteorology and Reservoir Operational Data. Hydrology section. Shiroro, Niger State, Nigeria

Sivongxay, A., Greiner, R., & Garnett, S. T. (2017). Livelihood impacts of hydropower projects on down-stream communities in central Laos and mitigation measures. *Water Resources and Rural Development* 9(4):6-55doi: 10.1016/j.wrr.2017.03.001.

Song, C., Gardner, K. H., Klein, S. J. W., Souza, S. P., & Mo, W. (2018). Cradle-to-grave greenhouse gas emissions from dams in the United States of America *Renewable and Sustainable Energy Reviews*. 90, 945–956. doi: 10.1016/j.rser.2018.04.014.

Sovacool, B. K., & Bulan, L. C. (2012). Energy security and hydropower development in Malaysia: The drivers and challenges facing the Sarawak Corridor of Renewable Energy (SCORE) *Renewable Energy 40*(1):113–129. doi: 10.1016/j.renene.2011.09.032.

Suleiman Y. M. and Ifabiyi I. P. (2014) The role of rainfall variability in reservoir storage management at Shiroro hydropower dam, Nigeria *International Journal of Science and Technology* 3(2):18 DOI: 10.43144/stech. v3i2.2

Tang, W., Zongmin, L., & Yan, T. (2018). Sustainability risk evaluation for large-scale hydropower projects with hybrid uncertaintyi,10(1). doi:10.3390/su10010138.

Varun, R. P., & Bhat, I. K. (2012). Life cycle greenhouse gas emissions estimation for small hydropower schemes in India. *Energy* 44(1): 498–508. doi: 10.1016/j.energy.2012.05.052.

Vassoney, E., Mochet, A. M., & Comoglio, C. (2017). Use of multicriteria analysis (MCA) for sustainable hydropower planning and management *Journal of Environmental management* 196:48-55 doi: 10.1016/j.jenvman.2017.02.067.

Zeng, R., Cai, X., Ringler, C., & Zhu, T. (2017). Hydropower versus Irrigation. An analysis of global patterns. *Environmental Research Letters*,12(3): 034006. doi:10.1088/1748-9326/aa5f3f

Zhang, J., Linyu, X., & Cai, Y. (2018). Water-carbon nexus of hydropower: The case of a large hydropower plant in Tibet, China. *Ecological Indicators* (92), 107–112 doi: 10.1016/j.ecolind.2017.06.019.

Remote Sensing and GIS-Based Vulnerabilities Assessment Over Borno State

Attahiru, I. M.[a] & Etim E.E.[b]
Department of Surveying and Geoinformatics, Federal University of Technology, Minna
[a]iliyasuattahiru86@gmail.com; [b]geoetim@gmail.com
Corresponding author: iliyasuattahiru86@gmail.com

Abstract:

Investigation of the pressing impact of climate change on drought is vital challenges for sustainable societal and ecosystem functioning and wellbeing. The magnitude by how the drought is going to change (dynamics) and the way drought is going to affect society and the environment are inadequately addressed over the north-eastern part of Nigeria. This study is aimed to investigate the effectiveness of remote sensing-based drought assessment system, examined the relations between rainfall and vegetation indices of drought and identified the most drought vulnerable areas using remote sensing (RS) and GIS technique in Borno State of Nigeria, which is a drought prone area. In this study 20 years data time series of SPOT at three epochs (2000, 2015 and 2020) Normalized Difference Vegetation Index NDVI and rainfall data were used. Vegetation indices; vegetation condition index (VCI) and Drought Severity Index (DSI) derived from SPOT were used for the study. Standardized precipitation Index (SPI) was calculated for 20years. The precipitation and temperature data, were sorted by months and years of observation. This allows for the visualization of the trend over years of observation. The result indicated that at the year 2030, the estimated extreme drought patch will record an upward growth 39.81%, the severe drought will record an increased growth in areas of 118.2%, the moderate patches will experience a downward movement in area of about -41.5%, while no drought and wet drought patches recorded an ascending trend pattern of 9.19% and 8.27% respectively. The outcomes of the projection have set a negative pace for the state agricultural practices and by extension the food chain produced in the state. However, the government should verify this claimed by using other methods to execute same project in other to create robust adaptive means for the indigene of the state to ease the food block chain process and other social amenities that may be affected

Keywords: Drought, Indices, Data, Vulnerability, Vegetation.

Introduction

Drought is one of the most globally recognized hazards that poses greater threat to the environment. It occurs when there is significant rainfall deficit that causes hydrological imbalances and affects the land productive systems. Drought practically occurs in all climate regions with both high and low mean rainfalls (Um *et al.*, 2017). It can result in damage to agricultural production as well as to that natural environment and human society (Gidey *et al.,* 2018). Drought is considered to be a natural disaster because it has a gradual creeping feature (Ayoade 1988; Yue *et al.*, 2018). Liu *et al.*, (2018) opine that drought develops slowly with prolonged effects that gradually increases in severity and tends to persist over a long period of time even after it has stopped. Analysis of the orbital photographs from National Aeronautics and Space Administration (NASA) shows that about 900,000 Kilometre square km2 of former savanna grass-land in the region of Africa has been severely decertified between the early 1960s and 1986 due to persistent drought occurrences (O'Connor (1995). Moreover, Bates *et al.*, (2008) state that one-third of African population lives in drought-prone areas. The drought has become a recurrent event in many parts of Africa, after the drought of the early 1970s that devastated the Sahel region. Dai *et al.,* (2004).

Many disciplinary perspectives of drought exist. Each discipline incorporates different physical, and/or socio-economic factors in its definition of drought (WMO, 2006).

The many definitions led to drought being group by type as follows: Meteorological, Hydrological, Agricultural and Socio-economic. These classifications are done according to a number of criteria involving several variables, used either alone or in combination; rainfall, temperature, humidity and evaporation from free water, transpiration from plants soil, moisture, wind, river and stream flow, and plant conditions.

Remote sensing is the science and art of obtaining information about an object, area or phenomena through the analysis of data acquired by a device that is not in contact with the object, area, or phenomena under investigation (Lillisand *et al.*, 2004).

The detection, monitoring and mitigation of disasters require gathering of rapid and continuous relevant information that are not effectively collected by conventional methods. Remote sensing tools and techniques make it possible to obtain and distribute continuous information rapidly over large areas by means of sensors operating in several spectral bands, mounted on air craft or satellites. A satellite, which orbits the earth.

Improvements in information technology have provided unimaginable opportunities to support data analyses and communications in the last two decades. GIS has provided new and exciting ways of acquiring natural resources data and also providing efficient means of processing, managing, integrating, and visualizing this data.

The following software packages were used for this study for graphical display and statistical analysis: Arc GIS, Arc Map 10.8, Global Mapper 18.0 SRT 1" dataset, Calculator, Microsoft Excel (statistical analysis), Microsoft Word (type setting).

METHODOLOGY

The methodology describes the steps taken to achieve the project's goals and objectives. This delves into four major processes: data acquisition, data processing, data analysis, and the display of various maps, charts, and tables defining the project's outcome.

Data Acquisition

For the purpose of the project, the following data were downloaded and used;

i. LANDSAT Imagery (Collection 7 and 8)

ii. Digital elevation model (DEM)

iii. Administrative boundary of Nigeria and states

iv. Monthly precipitation data for 20 years

v. Monthly temperature data for 20 years.

STATION DATA

The station data aspect covers the temperature and precipitation data sourcing. The data for these were downloaded from the NASA Power Data Access Viewer website (https://power.larc.nasa.gov/data-access-viewer/).

For the monthly precipitation and temperature data, thirty (30) sample station data were downloaded over a 20-year period.

DATA PROCESSING

Landsat Imagery

In processing the Landsat imagery, ArcMap 10.8 was used. Band 3 and 4 were uploading into ArcMap environment for Landsat 7, while band 4 and 5 was also uploaded for Landsat 8 data. The choice of band is driven by the parameters required when computing for NDVI.

The bands for each Landsat image were mosaiced separately using the mosaic raster tool in the data management toolbox of ARGMAP 10.3 software.

MOSAIC

An assembly of aerial photographs whose edges have been tom or cut and matched to form a continuous photographic representation of a portion of the Earth's surface. Often called "aerial mosaic".

In this study due to the size of the study area, it is often necessary to combine satellite imagery. The mosaic process facilitates such image relativity and orientation combinations (Francisco & Brain, 2007).

CLIPPING

Clipping is a result of capturing or processing an image where the intensity in a certain area falls outside the minimum and maximum intensity which can be represented. It is an instance of signal clipping in the image domain. The clipped area of the image will typically appear as a uniform area of the minimum or maximum brightness, losing any image detail. The amount by which values were clipped, and the extent of the clipped area, affect the degree to which the clipping is visually noticeable or undesirable in the resulting image.

(http://www.cambridgeincolour.com/tutorials/histograms1.htm)

The clipping feature allows the study area boundary to be defined using the existing state administrative layer. For such definition, the Borno State shapefile was used.

DEM

Digital Elevation Model (DEM) or digital surface model (DSM) is a 3D computer graphics representation of elevation data to represent terrain or overlaying objects, commonly of a planet, moon, or asteroid.

PRECIPITATION AND TEMPERATURE DATA

In terms of precipitation and temperature data, the data were organized by months and years of observation. This allows for the visualization of the trend over months and years of observation.

DATA ANALYSIS

DEM

The filled DEM data was further processed and classified through the ARCGIS Symbology tool using the stretch technique. This enables proper visualization and distinction in the variation of point elevations, grouping locations having elevation values closely related.

MEAN ANNUAL PRECIPITATION

To achieve the mean annual precipitation map, the station observation data for rainfall was added into the ArcMap environment. Using the longitude and latitude column as the X and Y column respectively, the point location was plotted through the Display XY tool.

The data plotted is further converted to shapefile for future manipulation and processing.

With the help of the kriging interpolation tool in the spatial analyst toolbox, an interpolation was done to create the final mean annual precipitation map.

The input point feature is the new point shapefile representing the observation stations, while the X value field was populated using the average precipitation data per annum. The study area boundary was used as the processing extent after which the ok button was clicked to produce the final result.

MEAN ANNUAL TEMPERATURE

The mean annual temperature map was produced using the processes listed above in the creation of the mean annual precipitation map. In the case of the kriging interpolation, the average monthly temperature per annum was used as the Z value field.

Standard Precipitation Index

The standard precipitation index map was produced using the precipitation station observation data and applying the Inverse Distance Weighting. The use of the geostatistical wizard was employed for this purpose. The point shapefile was used as the point dataset while the XY and average precipitation were used for the required parameters as shown in figure 3 below. The neighborhood type was set to standard while maintaining other parameters. The standard precipitation map was produce showing the degree of rainfall as it relates to drought.

RESULT

The result reflects the output obtained from the processes stated above.

DEM

Following the field process to aid in the smoothening of the digital elevation model, a final map depicting the nature of the terrain while taking elevation into account was created. This is shown in the Figure 1;

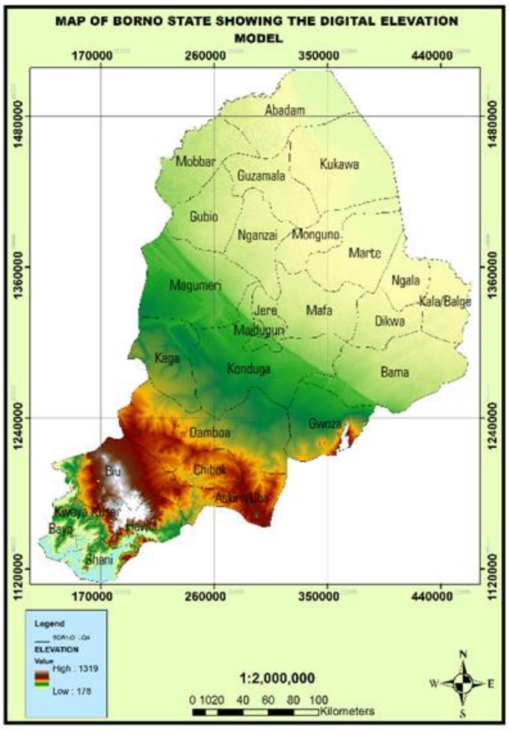


Figure 1 The digital elevation model of Borno State classified using the stretch technique to show the variation in the elevation of different points.

Figure 1 shows that the majority of the northern part of the state has higher elevation values when compared to the southern part of the state, with locations such as Biu and Hawul falling within the white region, which represents the highest elevation value.

When considering precipitation and temperature of locations, the elevation of the state plays a significant role, which also has an adverse effect on the condition of the vegetation within the location.

Temperatures drop at higher elevations because the higher you go in the atmosphere, the colder it gets due to air pressure, causing precipitation to freeze and form snow. Lower elevations are much warmer because the air pressure is lower, causing the temperature to rise. Likewise, the precipitation (Prezi, 2023)

NDVI

The Normalized Difference Vegetation Index was created, and the vegetations were divided into three categories based on a threshold of -1 to 0.1, 0.1 to 0.4, and 0.4 and higher. The first threshold identifies areas with no vegetation, the second identifies areas with shrubs and grasses, and the last identifies areas with dense vegetation.

Non-Vegetation

Shrub/Grasses

Dense Vegetation

The raster data was reclassified with the above stated thresholds to achieve the given result.

The table below further explains the changes that has occurred between the year 2000 and 2020;

Table 1 Showing the statistical data of year 2000 NDVI

CATEGORY	COUNT	AREA(Ha.)	PERCENTAGE
NON-VEGETATION	507174	45645.66	0.63
SHRUBS/GRASS	77959387	7016344.8	96.96
DENSE VEGETATION	1936739	174306.51	2.41
TOTAL	**80403300**	**7236297**	**100.00**

The extent of each category can be seen in the Table above, with shrubs and grasses having the highest percentage of 96.96, dense vegetation area covering a total percentage of 2.41, and non-vegetation zone having the lowest percentage of 0.63.

The area in hectares of each category was computed using the count value. The count value represents the number of pixels covered by each category. Knowing the resolution of the LANDSAT image which 30m, this makes the area of each pixel to be computed as follows;

Area of each pixel in square meters = 30m x 30m

= 900 SqM

Therefore;

Area of each pixel in hectares = 900/10000

= 0.09 Hectares per Pixel.

Now, to get the area of each category, the count value is multiplied by 0.09 hectares.

Table 2 Showing the statistical data of 2020 NDVI

CATEGORY	COUNT	AREA(Ha.)	PERCENTAGE
NON-VEGETATION	25299880	2276989.2	31.47
SHRUBS/GRASS	54948621	4945375.9	68.34
DENSE VEGETATION	154807	13932.63	0.19
TOTAL	**80403308**	**7236297.7**	**100.00**

As shown in the table above, the area covered by each category has changed, though the highest percentage still remains shrubs and grasses with a percentage of 68.34, followed by non-vegetation with a percentage of 31.47, and dense vegetation with a percentage of 0.19.

Table 3 Showing the changes that occurred in the three categories between the year 2000 and 2020.

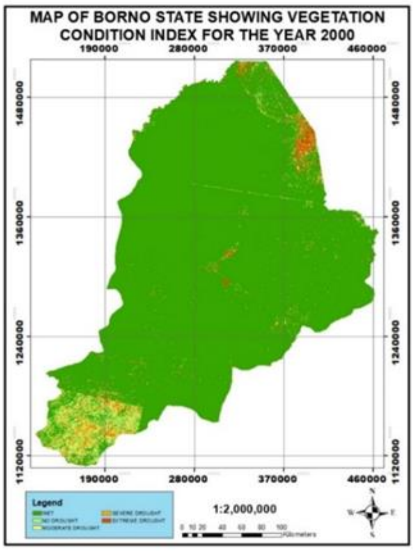
CATEGORY	AREA (Ha.) 2000	2020	AREA LOSS/GAIN	PERCENTAGE LOSS/GAIN	REMARK
NON-VEGETATION	45645.66	2276989	2231343.54	30.84	GAIN
GRASS/SCRUBS	7016345	4945376	2070968.94	-28.62	LOSS
DENSE VEGETATION	174306.5	13932.63	160373.88	-2.22	LOSS
TOTAL	7236297	7236298			

The table above makes comparison between the NDVI result of 2000 and 2020. The percentage gain/loss explains the level of change that occurs in each category. Non-vegetation had a gain of 30.84% confirming a loss in both shrubs/grass, and dense vegetation. The major loss was recorded in the shrubs/grass category with 28.62% loss, while the dense vegetation had a loss of 2.22%. The result of this comparison confirms the categories which have lost area coverage and those which have gained within the 20 years period. The gain in non-vegetation category signifies a lost in vegetation which also signifies a change in climate, pressure from human activities, and other environmental factors.

The white patches indicate areas which are non-vegetations, from water to bare soil, rocks, buildings, roads, and other human creations. The lighter green represents the shrubs/grass category, while the dense vegetation is represented with the dark green colour as shown in figure 2 and 3 above.

Vegetation Condition Index

The vegetation index was computed and the raster data reclassified into 5 major categories, the extreme drought, severe drought, moderate drought, no drought, and wet. This has been classified using the threshold stated below;

(a) 

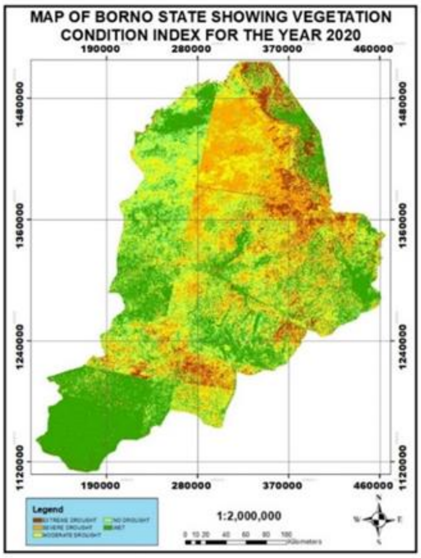
(b) 

Figure 2: *NDVI for the study area: (a) Year 2000 and (b) Year 2020*

The maps shown in figure 2 have been summarized into Table 4 to aid understanding of the statistical values.

Table 4: Summary of NDVI as Presented in Figure 2 (a) Year 2000

CATEGORY	COUNT	AREA(Ha.)	PERCENTAGE
EXTREME DROUGHT	1901777	171159.93	2.344639264
SEVERE DROUGHT	1232292	110906.28	1.519252892
MODERATE DROUGHT	1661240	149511.6	2.048088987
NO DROUGHT	1901777	171159.93	2.344639264
WET	74414624	6697316.2	91.74337959
TOTAL	**81111710**	**7300053.9**	**100**

From Table 4, the highest coverage is the wet zone with a total percentage of 92.55, then the No Drought zone having a total coverage percentage of 2.37. The least category is the Extreme Drought zone with a percentage of 1.48. the table gives a total drought overview within the study area in the year 2000.

Table 5: Summary of NDVI as Presented in Figure 2 (a) Year 2020

CATEGORY	COUNT	AREA(Ha.)	PERCENTAGE
EXTREME DROUGHT	5686493	511784.37	7.07245745
SEVERE DROUGHT	15504446	1395400.1	19.28333238
MODERATE DROUGHT	16896441	1520679.7	21.01459723
NO DROUGHT	15356472	1382082.5	19.0992928
WET	26959502	2426355.2	33.53032014
TOTAL	**80403354**	**7236301.9**	**100**

The wet area has a drop in coverage in 2020, with a total percentage of 33.53, while the extreme drought category has the lowest percentage coverage, with a figure of 7.07%. When compared to the year 2000 statistics, there has been a significant decrease in the area of wet zone, but this will be better appreciated in the table below.

Table 6: Comparison between the 2000 and 2020 vegetation condition index.

CATEGORY	**AREA (Ha.)**		**AREA**	**PERCENTAGE**	**REMARK**
	2000	**2020**	**LOSS/GAIN**	**LOSS/GAIN**	
EXTREME DROUGHT	171159.9	511784.4	340624.44	4.686517661	GAIN
SEVERE DROUGHT	110906.3	1395400	1284493.86	17.67284567	GAIN
MODERATE DROUGHT	149511.6	1520680	1371168.09	18.8653623	GAIN
NO DROUGHT	171159.9	1382083	1210922.55	16.66060696	GAIN
WET	6697316	2426355	4270960.98	-58.76247184	LOSS

To determine the gain and loss, the result of 2000 was subtracted from that of 2020 and the percentage calculated. From the statistical result, 58.76% of wet zone were lost while the extreme drought zone gained by 4.69%. this shows that's there has been high pressure and stress on the vegetations resulting to such loss.

Mean Annual Precipitation

The mean annual precipitation map shows the variation in the level of rainfall in different locations within the study area (Borno State). This is a combination of the monthly precipitation data of each year from 2000 to 2020.

The trends have been classified into 10 classes to have a better spread in visualizing the details of the precipitation around the different local governments. The southern part of the start has higher precipitations between year 2000 to 2020 as compared to the northern part of the state with the least precipitation amount.

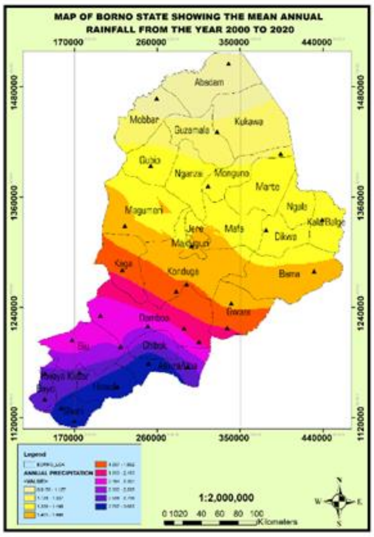


Figure 3 Map showing the mean annual precipitation in Borno State from year 2000 to 2020.

Comparing the mean annual precipitation map with the 2020 NDVI and VCI, the relation can be drawn considering the low precipitation towards the northern part of the study area and the high lost of vegetation cover towards the northern part also.

Mean Annual Temperature

The mean annual temperature also depicts the variation in temperature all around the study area, this was obtained from the cumulation of the monthly temperature data from year 2000 to 2020.

Similar to the trend in the precipitation map, the temperature map gives a clear visual and it can be observed that the northern part of the study area experiences higher temperature than the southern part of the state and this is likely to contribute to loss in vegetation around the northern part of the state.

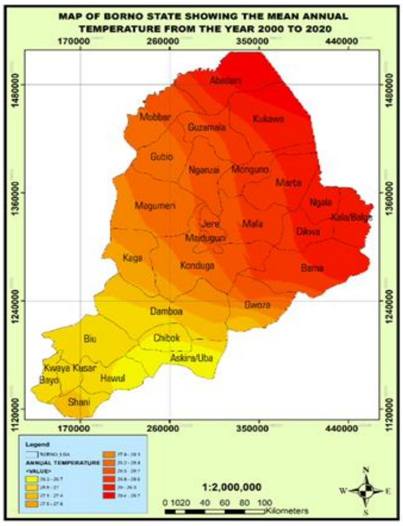


Figure 4 The temperature variation within Borno State between the year 2000 and 2020.

Standard Precipitation Index

The standard precipitation index further defines the level of drought using the precipitation data of the study area from year 2000 to 2020. This was classified using already established thresholds listed on the table below;

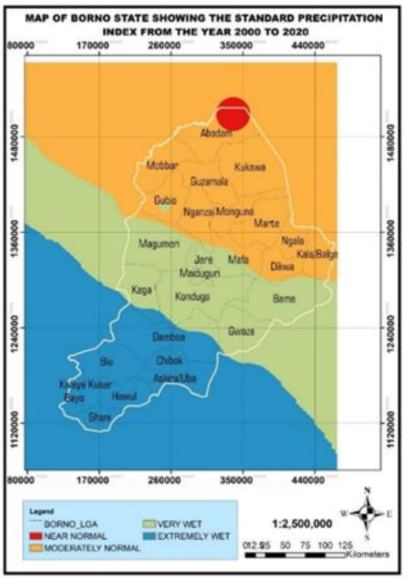


Figure 5 Standard precipitation index further classifying the level of drought within the study area.

Conclusions

Northern Nigeria, particularly Borno State is frequently affected by drought. Temporal and spatial extents and characteristics of drought can be noticed, monitored and mapped from remotely sensed data and vegetation data. The Remote Sensing based drought indices were effective in drought assessment in the arid and semi-arid areas. The present study has revealed that drought vulnerable areas can be delineated using Normalized Difference Vegetation Index and Vegetation Condition Index derived from vegetation data. Vegetation Condition Index is harmonizing found to be sensitive indicator of drought conditions. In addition, Standardized Precipitation Index from the satellite rainfall data was effective in drought assessment in Borno State.

The findings of this study can be used for improvement of drought monitoring scheme. Taking into account the spatial extension and frequency of drought and lack of timely ground data observations, the application of remotely sensed data could play a key role for drought monitoring and drought prediction.

Acknowledgements

I am thankful to the Almighty Allah for the divine blessings showered up on me to complete this work. I would like to express my gratitude and appreciation to my advisor Dr. Etim Efiong Eyo of the Department of Surveying and Geoinformatics, School of Environmental Technology, Federal University of Technology, Minna.

I am also thankful to Dr. Yusuf D. Opaluwa of the Department of Surveying and Geoinformatics, School of Environmental Technology, Federal University of Technology, Minna for his advice and encouragements towards the pursuit of my academic certificate.

I am greatly indebted to my parents Alh. Attahiru D. Mali & Hajiya Jummai Lappa for their support and encouragement throughout my studies. My special appreciation also goes to my dear wife Khadija Abubakar and my four lovely children Fareed, Attahiru, Alhassan & Saudah, who stood by me through thick and thin through the period of my study.

References

Ayoade, J.O. 1988. On Drought and Desertification in Nigeria. In Environmental Issues and Management in Nigerian Development, ed. P.O. Sada and F.O. Odemerho, 271–290. Ibadan: Evans Brothers (Nigerian Publishers) Limited.

Bates, B.C., Kundzewicz, Z.W., Wu, S.and Palutikof, J.P. (Eds). (2008). Climate Change and Water. Technical Paper of the Intergovernmental Panel on Climate Change, IPCC Secretariat, Geneva. Available from https://www.ipcc. ch/pdf/technical-papers/climate-change-water-en.pdf - 28/doc13.pdf (accessed: June, 2018).

Dai, A., P.J. Lamb, K.E. Trenberth, P. Hulme, D. Jones, and P. Xie. 2004. The recent Sahel drought is real. International Journal of Climatology 24: 1323–1331.

Francisco, G. R., & Brain, R. (2007). Towards Optimal Mosaicking of Multi-Spectral Images. *NASA Pan-American Center for Earth and Environmental Sciences (PACES)*, 01.

Gidey, E., O. Dikinya, R. Sebego, E. Segosebe, and A. Zenebe. 2018. Analysis of the long-term agricultural drought onset, cessation, duration, frequency, severity and spatial extent using vegetation health index (VHI) in Raya and its environs, northern Ethiopia. Environmental Research System 7 (13). https://doi. org/10.1186/s40068-018-0115-z

Lillisand, T.M., Kierfer, R.W. and Chapman, J. w. (2004). *Remote sensing and image interpretation* (5th ed.). John Willey & Sons Inc. Hobooken, NJ, USA.

Prezi. (2023, January 15). *How Elevation affects Precipitation and Temperature.* Retrieved from Prezi: https://prezi.com/af0gfjxerwbd/how-elevation-affects-precipitation-and

Drought Analysis in Jega Local Government, Kebbi State, Using Geospatial Tools to Analyse Vegetation Covers

Yahaya I. A.[1a] & Etim E. E.[1b]
Department of Surveying and Geo-informatics, Federal University of Technology, Minna, Nigeria.
yahayaibrahimabdulsalam@gmail.com; (07037473177); geoetim@gmail.com (08036224676)

Abstract:

Drought is a natural menace caused by low temperature which populace of Jega Local Government, Kebbi State their health and farmland. This research focused on applying GIS and Remote Sensing in monitoring the drought in Jega through LULC, NDVI, NDWI, LST, VCI and VHI. The LULC was carried out using Sentinel 2, band 11, 8, 4 for its maximum likelihood supervised classification, sentinel 2 was also used to carry out its NDVI using band 8 and 4, NDWI using band 8 and 3, sentinel 3 was also used to carry out the LST of the study area using SNAP and ArcMap, NDVI was used to carry out the VCI for this study, while LST was used to carry out the TCI, hence, both VCI and TCI were incorporated to determine the VHI for this study. Result showed that bare land had reduced drastically in the last seven years of the study area, while vegetation increased but had low chlorophyll, the NDVI in the last 7 years shows that the vegetation have moderate chlorophyll as the maximum value falls between 0.6 to 0.7, NDWI shows a poor water condition in the study area as the NDWI values are not up to 0.3, similarly, LST in the study area has been bad having had higher values in 2016 and 2019 but a moderate one in 2022, while the VCI and VHI shows a severe drought in 2016 and 2019 but a low one in 2022. Conclusively, this Research had successfully analyzed the drought situation in Jega local Government, Kebbi State geospatially.

Keywords: Drought, {NDVI "Normalized Difference Vegetation Index"}, {NDWI "Normalized Difference Water Index"}, {LST "Land Surface Temperature"}, {SNAP "Sentinel Application Platform"}.

Introduction

Drought is a period of drier-than-normal conditions that results in water-related problems. The amount of precipitation at a particular location varies from year to year, but over a period of years, the average amount is fairly constant. When little or no rain falls, soils can dry out and plants can die. When rainfall is less than normal for a period of weeks to years, stream flows decline, water levels in lakes and reservoirs fall, and the depth to water in wells increases. If dry weather persists and water-supply problems develop, the dry period can become a drought. Droughts occur when there is abnormally low rainfall for an extended period of time. This means that a desert would not be considered in drought unless it had less rainfall than normal for a long period of time. Droughts can last from weeks to months and even years. Droughts can occur all over the world. However, there is a link between drought and some climate patterns. A lack of water vapor in the atmosphere means there is less precipitation and more chance of drought. High-pressure systems reduce evaporation and moisture in the atmosphere. According to Zolotokrylin, A.N., (2010), drought is an environmental menace that causes damage to life and properties, which is a temporary condition when water require of a hydrological system exceeds the income of water from any origin. Drought is a destructive agent under the influence of natural factor which leads to meal crisis, loss of life, property degradation (Dhaifallah, et al., 2018).

Study Area: Figure 1 shows the study area, Jega Local Government, Kebbi State, Nigeria.

Materials and Method

Materials

Table 1 shows the full data used in this research, the data were acquired on different days and from different sources as indicated in the table.

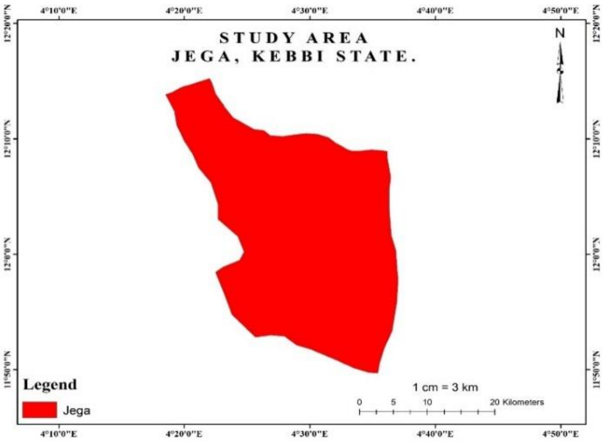


Figure 1: Study Area.

Table 1 : Data acquired for the Research

S/N	Dataset	Scale/ Resolution	Source	Coordinate System	Acquisition Date
1	Nigeria Shapefile		Diva-GIS (*https://www.diva-gis.org/gdata.*)	GCS_WGS1984 UTM Zone 31N	10th January, 2022.
2	Sentinel-2	10m	*https://Developers.google.com/earth-engine/datasets*		15th January, 2022.
3	Sentinel-3	10m	*https://scihub.copernicus.eu/dhus/#/home*		21st January, 2022

Method

Land use cover

The Land Use cover of the study area was carried out in other to have a thorough observation of the vegetation health condition in the study area, Jega, Kebbi State.

The acquired Sentinel imageries were imported into the ArcMap environment, and band composite was finally carried out on the imagery with bands 11, 8, 4 combinations, the study area was clipped out from the imageries. Maximum likelihood supervised classification was then applied to the clipped imagery in the ArcMap environment mapping four major classes such as Built-up, Bare land, Vegetation, Water body, using the Classification Scheme deduced by Anderson (1971).

Indices maps

The NDVI for the years 2016, 2019 and 2022 was calculated using the equation by Gandhi, G. Meera, et al. (2015);

$$\text{NDVI} = \frac{\text{NIR}-\text{RED}}{\text{NIR}+\text{RED}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Band 8 and 4 of the sentinel image were used to carry out the NDVI. After the Bands had been clipped, the process was executed under the; Spatial Analyst Tool<Map Algebra<Raster Calculator.

The NDWI for the years 2016, 2019 and 2022 was calculated using the equation by Xu, H. (2006)

$$\text{NDWI} = \frac{(\text{NIR} - \text{SWIR})}{(\text{NIR} + \text{SWIR})} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Band 8 and 3 of the sentinel images were used to carry out the NDWI. After which the Bands had been mosaic and clipped, it was then run under the; Spatial Analyst Tool<Map Algebra<Raster Calculator.

Zheng, *et al*. (2019) acquired its LST data through the Sentinel-3A Sea and Land Surface Temperature Radiometer (SLSTR), it then reported that the SLSTR provides global daily coverage of day and night observation in the wavelength range of 0.55 to 12.0 µm. Hence, this research acquired its LST data from the SLSTER using the SNAP software for its execution.

Masitoh *et al*. (2019) reported that the VHI is one of the remote sensing and GIS tool use for drought analysis, its research adopted a mathematical approach which is stated below, as it used the value of 0.5 for constant α.

$$VHI = \alpha . VCI + (1 - \alpha)\ TCI \ldots\ldots\ldots\ldots\ldots \quad (3)$$

Where;

VCI: Vegetation Condition Index, which uses the NDVI for its execution.

$$VCI = NDVI - NDVImin / NDVImax - NDVImin * 100 \ldots\ldots\ldots \quad (4)$$

TCI: Temperature Condition Index, which uses the LST for its execution.

$$TCI = BTmax - BT / BTmax - BTmin * 100 \ldots\ldots\ldots \quad (5)$$

Result and Discussion

Land use cover

Table 2 shows the land cover change of the study area within an epoch of seven years. The result showed that Vegetation, Built Up and Water body had increased in the last seven years of the study area, while bare land had drastically reduced. Figures 2 (a - c) showed the study area's land use/land cover map within the last 7 years.

Table 2: Land Use/Land Cover changes for the year 2016, 2019 and 2022

LULC 2016			**LULC 2019**		**LULC 2022**	
Name	**Area (km^2)**	**Percent (%)**	**Area (km^2)**	**Percent (%)**	**Area (km^2)**	**Percent (%)**
Water Body	5.75	0.64	7.52	0.92	10.19	1.71
Vegetation	426.32	47.33	471.40	51.99	515.17	57.39
Built Up	70.23	7.80	78.51	9.26	84.73	9.66
Bare Land	398.50	44.24	343.38	37.84	290.71	31.24

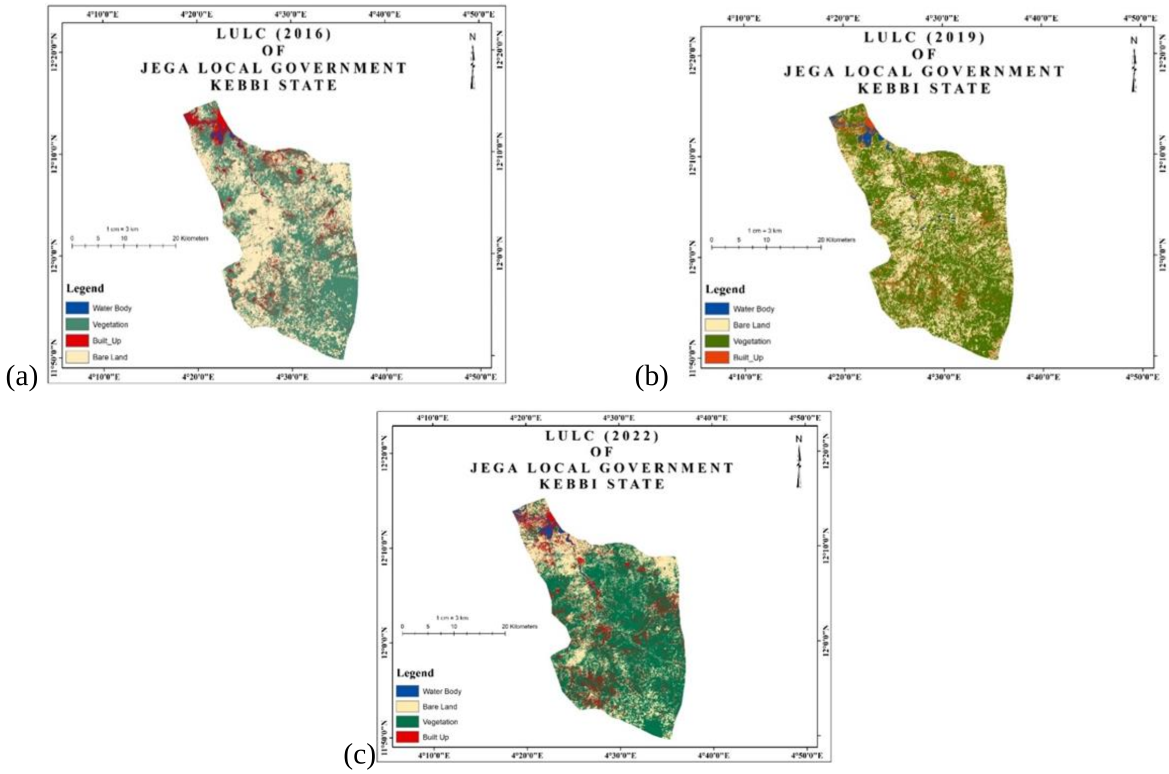


Figure 2: Land use/land cover map of the study area within the last 7 years. (a).2016; (b).2019 and (c) 2022

Indices maps

Table 3 shows the NDVI results of the study area within an epoch of seven years. The figure 3 showed the NDVI map of the study area within the last 7 years. According to Gandhi, G. Meera, et al. (2015), he stated that the range of NDVI values obtained is between −1 and +1, and only positive values correspond to vegetated zones; the higher the index, the greater the chlorophyll content of the target. Hence, the result shows that, vegetation health has been moderate but not really sound in the last seven years in the study area.

Table 3: NDVI values for the year 2016, 2019 and 2022

YEARS	Minimum	Maximum	Indication
2016	-0.055	0.643	Moderate Vegetation
2019	-0.242	0.745	Moderate Vegetation
2022	-0.222	0.743	Moderate Vegetation

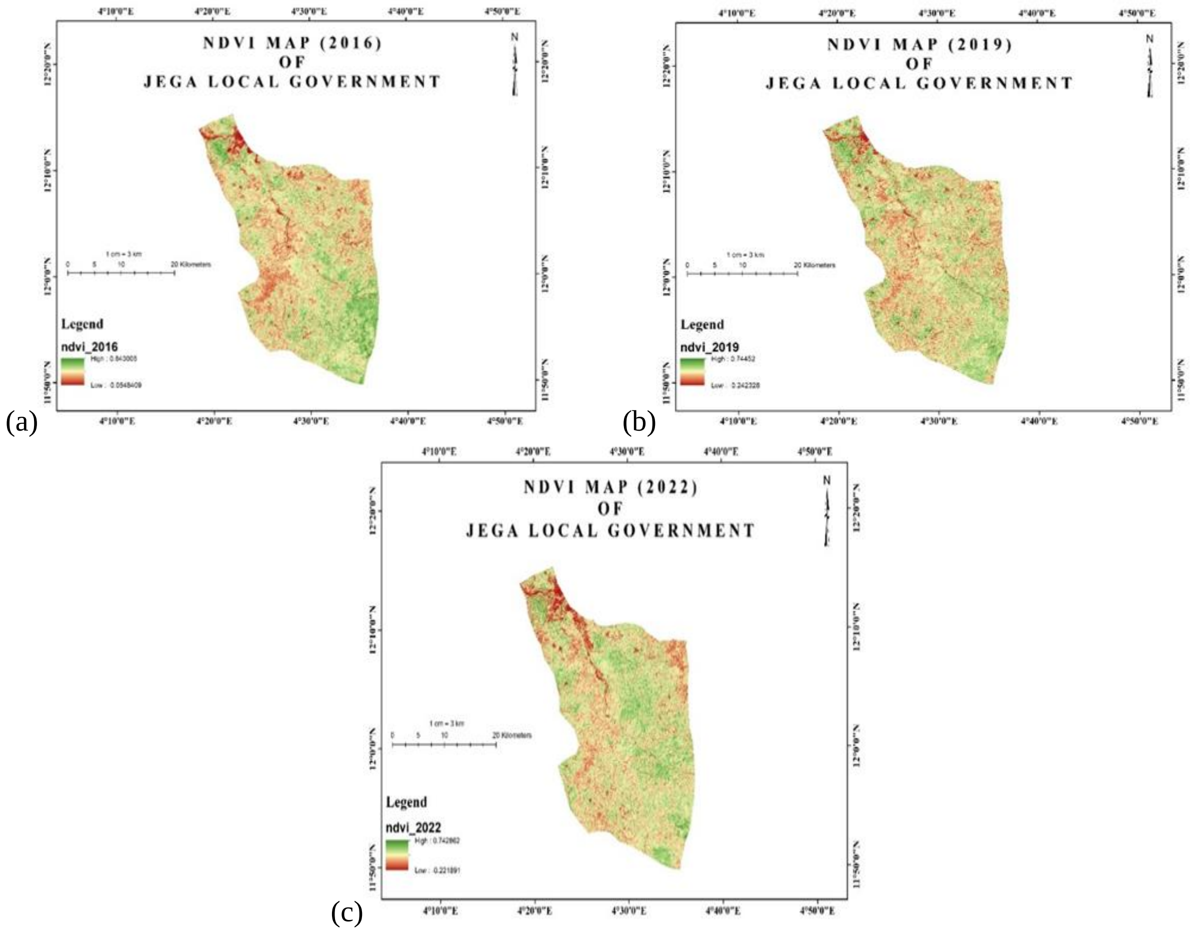


Figure 3: NDVI Map of the study area within the last 7 years: 9a0 2016; (b) 2019 and (c) 2022

Table 4 shows the NDWI results of the study area within an epoch of seven years. Figure 4 showed the NDWI map of the study area within the last 7 years. Gu, Yingxin, et al. (2008) reported that values of NDWI greater than zero predict areas with water surfaces, while values less than or equal to zero are assumed to be non-water surfaces.

Table 4: NDWI values for the year 2016, 2019 and 2022

YEARS	Minimum	Maximum	Indication
2016	-0.551	-0.008	Very low water
2019	-0.625	0.218	Low water
2022	-0.633	0.231	Low water

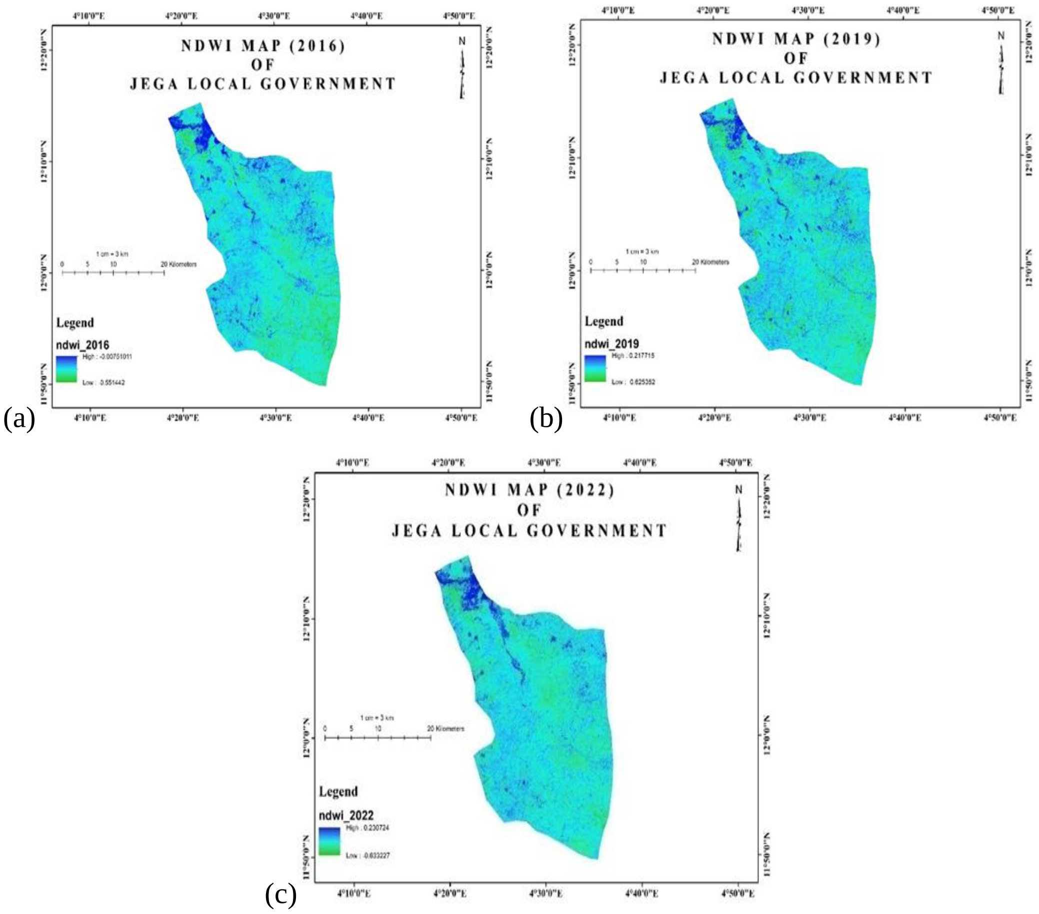


Figure 4: NDWI Map of the study area within the last 7 years: (a) 2016; (b) 2019 and (c) 2022

Table 5 shows the VCI of the selected years (2016, 2019 and 2022) estimated and were found between 0 – 100, figure 5 shows the VCI map of the study area within the last 7 years. Yulistya, V. D et al. (2019) reported that the VCI ranges from 0 to 100, if the VCI ranges from 70 to 100, it indicates normal vegetation conditions and no drought. A value between 50 and 70 indicates moderate vegetation conditions and mild drought, whereas a value from 30 to 50 indicates poor vegetation growth and moderate drought, and below 30 indicates extremely poor growth conditions and severe drought.

Table 5: VCI values for the year 2016, 2019 and 2022

YEARS	**Minimum**	**Maximum**	**Indication**
2016	0	100	Severe Drought
2019	0	100	Moderate Drought
2022	0	100	Low Drought

Table 6 shows the VHI of the selected years (2016, 2019 and 2022) were estimated and were found between 0 – 100, the figure 6 showed the VHI map of the study area within the last 7 years. Sholihah, Rizqi I., et al. (2016) reported that the VHI ranges from 0 to 100, if the VHI ranges from 40 to 100, it indicates normal vegetation conditions and no drought, value between 30 and 40 indicates moderate vegetation conditions and mild drought, whereas a value from 20 to 30 indicates poor vegetation growth and moderate drought, 10 and 20 indicates poorer vegetation growth and severe drought, and below 10 indicates extremely poor growth conditions and Extreme drought.

Table 6: VHI values for the year 2016, 2019 and 2022

YEARS	**Minimum**	**Maximum**	**Indication**
2016	0	50	Extreme Drought
2019	0	79	Severe Drought
2022	50	100	Low Drought

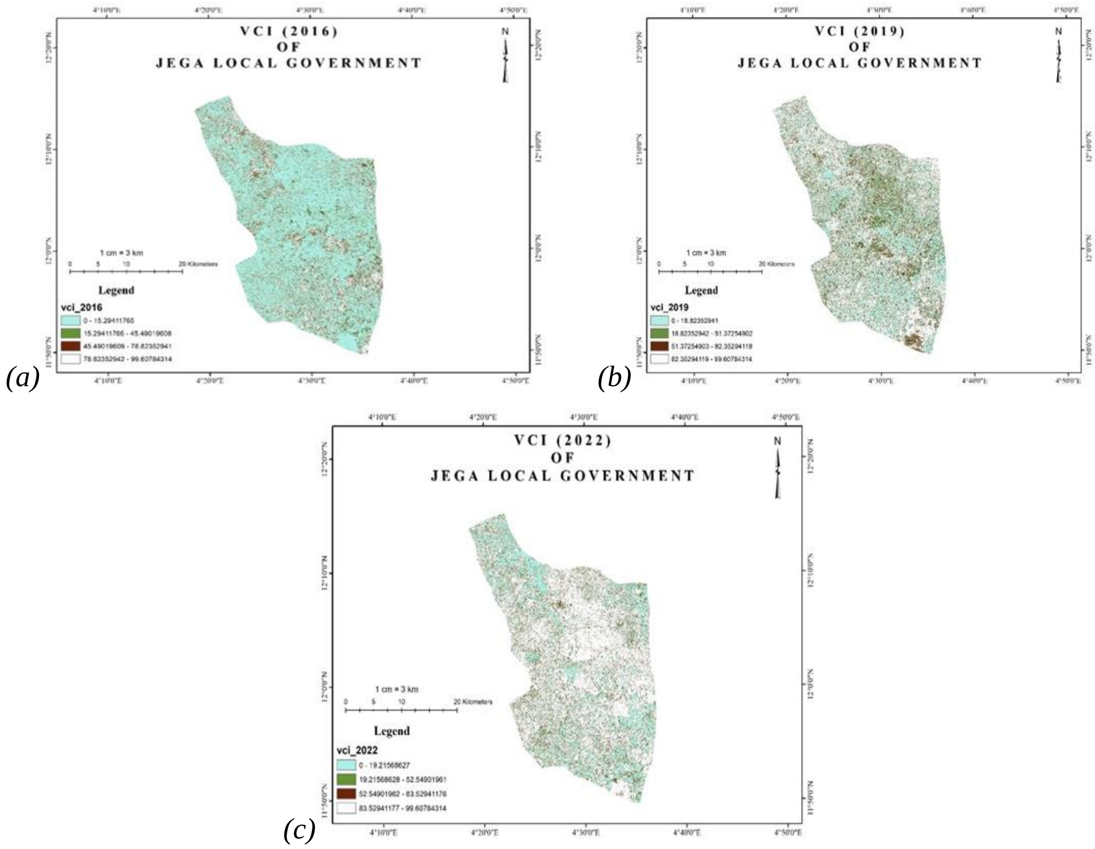


Figure 5: VCI Map of the study area within the last 7 years:(a) 2016; (b) 2019 and (c) 2022

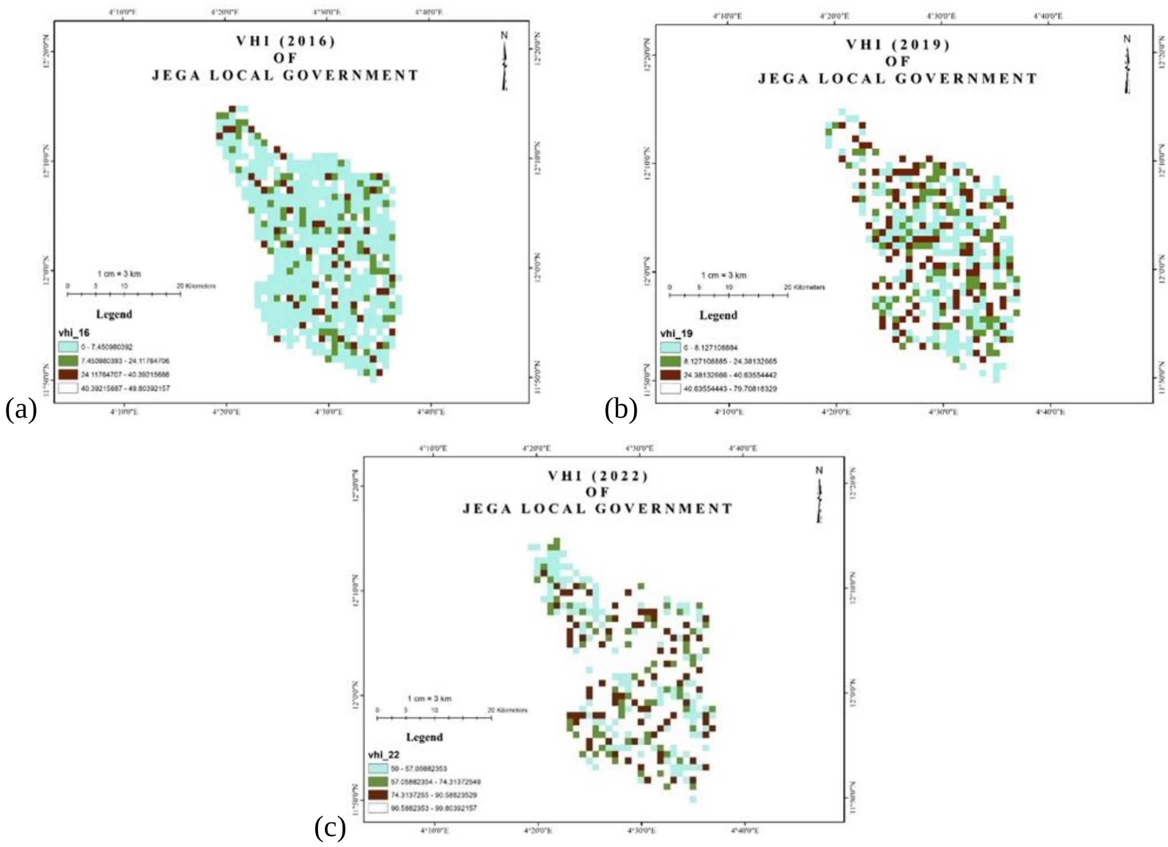


Figure 6: VHI Map of the study area within the last 7 years: (a) 2016; (b) 2019 and (c) 2022

Conclusions

This study shows that GIS and Remote Sensing are better tools to study any environmental hazard, as it adopted the NDVI, NDWI, LST, VCI and VHI to carry out drought analysis in Jega Local Government, Kebbi State. The Land Use Cover in the study area shows reduction in its bare land which shows a good result for development in terms of building. Similarly, the LST results showed that the Surface Temperature was higher in 2016 and 2019 while it got reduced in 2022. The VCI and VHI showed higher drought in 2016 and 2019 but low drought in 2022 which shows that drought had been a serious issue in the past 7 years in the study area.

References

Anderson, J.R. (1971). Spatial Diversification of High-Risk Sheep Farms, in J.B. Dent and J.R. Anderson, eds., system analysis in Agricultural management. 239 - 266.

Dhaifallah, Ali Ahmed Ali, Noorazuan Bin MD Hashim, and Azahan Bin Awang. "Drought risk assessment using remote sensing and GIS in Yemen." *International Journal of Engineering & Technology* 7, no. 2.29 (2018): 586-592.

Gandhi, G. Meera, B. S. Parthiban, Nagaraj Thummalu, and A. Christy. "Ndvi: Vegetation change detection using remote sensing and gis–A case study of Vellore District." *Procedia computer science* 57 (2015): 1199-1210.

Gu, Yingxin, Eric Hunt, Brian Wardlow, Jeffrey B. Basara, Jesslyn F. Brown, and James P. Verdin. "Evaluation of MODIS NDVI and NDWI for vegetation drought monitoring using Oklahoma Mesonet soil moisture data." *Geophysical Research Letters* 35, no. 22 (2008).

Masitoh, F. and Rusydi, A.N., 2019, November. Vegetation Health Index (VHI) analysis during drought season in Brantas Watershed. In *IOP Conference Series: Earth and Environmental Science* (Vol. 389, No. 1, p. 012033). IOP Publishing.

Sholihah, R. I., Trisasongko, B. H., Shiddiq, D., La Ode, S. I., Kusdaryanto, S., &Panuju, D. R. (2016). Identification of agricultural drought extent based on vegetation health indices of landsat data: case of Subang and Karawang, Indonesia. *Procedia Environmental Sciences*, *33*, 14-20.

Xu, Hanqiu. "Modification of normalised difference water index (NDWI) to enhance open water features in remotely sensed imagery." *International journal of remote sensing* 27, no. 14 (2006): 3025-3033.

Yulistya, V. D., Wibowo, A., &Kusratmoko, E. (2019, August). Assessment of agricultural drought in paddy field area using Vegetation Condition Index (VCI) in Sukaresmi District, Cianjur Regency. In *IOP Conference Series: Earth and Environmental Science* (Vol. 311, No. 1, p. 012020). IOP Publishing.

Zheng, Y., Ren, H., Guo, J., Ghent, D., Tansey, K., Hu, X., Nie, J. and Chen, S., 2019. Land surface temperature retrieval from sentinel-3A sea and land surface temperature radiometer, using a split-window algorithm. *Remote Sensing*, *11*(6), p.650.

Zolotokrylin, A.N., 2010. Droughts: Causes, distribution and consequences. *Natural Disasters*, *1*, p.239.

Flood Vulnerability Mapping of Communities Along River Kaduna in Lavun Local Government Area, Nigeria

Mohammed, A.B. Y.[1a] & Onuigbo, I.C.[1b]
[a]abyahya1515@gmail.com; [b]onu@futminna.edu.ng
Department of Surveying and Geoinformatics, Federal University of Technology Minna, Niger State
Corresponding author: abyahya1515@gmail.com

Abstract.

This study focuses on the use of geospatial methods and passively observed data to describe the flood risk of some communities in Lavun LGA, Niger State, Nigeria. Along the Kaduna River in Lavun LGA, the regions and communities most vulnerable to inundation are identified using the spatial analytic capabilities of geographical Information System (GIS). SRTM 30 m imagery of the research region was used to derive various datasets. The geographic studies were conducted using ArcGIS 10.3. Additionally, 3D analysis, digital topography modelling (DTM), buffering, and layer operations were carried out. An area of 1346.625 km^2 (47.7%) in the Lavun LGA contains floodplains with heights between 172 m and 267 m above sea level that are designated as "vulnerable" to inundation. While highland regions between 383 and 744 meters above sea level were designated as "not vulnerable," spanning 346.72 km^2 (12.23%) of the total territory. Based on their geographic placements within specific buffer zones, some communities downstream of Shiroro Dam were also assessed for flood risk. The following suggestions were made in light of the findings: Automated mapping and analysis of the Lavun LGA's terrain are being done in order to create a data bank and a master plan for the LGA's monitoring and management of flood disasters. Comprehensive data are also being produced, along with periodic reviews of all the communities included in the study that are at risk for flooding, to aid in making decisions quickly, especially in times of flood disaster. The study came to the conclusion that the flood catastrophe risk of the study area was successfully assessed using remotely sensed data and GIS methods for floodplain mapping in Lavun LGA.

Key words: Floodplain, Vulnerability, Geospatial Technologies, DEM.

Introduction

Globally, floods typically happen when there is more precipitation than what the earth and plants can hold. In other words, more rainfall than rivers, streams, ponds, and wetlands can hold drains off the ground. When such heavy rainfall occurs, rivers and streams occasionally exceed their banks and spread onto the nearby floodplains (Luka, 2015; Adewuyi, 2014). Floods pose a serious threat to people living near waterways and floodplains, as well as having a significant negative effect on the ecosystem, including bank erosion and the deterioration of aquatic life (Bronstert, 2013; Anyanwu, 2015).

Fundamentally, there are many various ways to view floodplains. "The goals in mind rather determine how to define a floodplain." It belongs to the topographic category of flat land that is next to a stream; it is primarily made up of sediments transported by the related stream in the form of unconsolidated depositional material; and hydrologically, it is best described as a landform that is periodically inundated by the parent stream. These qualities may be combined to meet the necessary standards for identifying the watershed (Karki *et al.*, 2011).

A floodplain is also described as "a strip of relatively smooth land bordering a stream and overflowing at a time of high water" (Webster's New World Dictionary). "Gwaram et al." (2014) Floodplains are the areas of territory closest to rivers and waterways that experience frequent flooding. As a result, floodplains are "flood-prone" and dangerous for growth activities if their degree of vulnerability is too high.

Flood hazard maps depict the scope of flooding based on research into flooding at the specified place. The level of the water typically determines the scope and intensity of flood damage. Geospatial methods on a GIS platform can be used to successfully and quickly carry out such an analysis. Additionally, this offers a structure for a decision-support system and makes it easier to assess different flood control options (Abiodun, 2014; Panda and Sahoo, 2015; Psomiadis, Diakakis, and Soulis, 2020).

The number of projects along river courses and the accumulation of people near floodplains both contribute to an ongoing rise in the damages caused by flooding. The construction of roads and bridges in the floodplain as well as land clearance for farmland or urban development are increasing the flood's severity. Floodplains and flood-prone areas need to be closely examined in view of how they might impact or be affected by development due to their constantly changing character.

The absence of precise hydro-meteorological data and inadequate geographic data on the size of the floodplain in the Lavun LGA both contribute to the ambiguity surrounding flash flooding occurrences. In order to create efficient prevention strategies to safeguard these regions from flooding, it is essential to chart the length and influence of the floodplain. In Nigeria, where flooding is prevalent, information on the effects of flooding at the national, city/state, or local level may be missing, or flood event records may not be full, making it challenging to compare the impacts across places and determine their size (Etuonovbe, 2011; Psomiadis, Diakakis, Soulis, 2020; Hussain, Sajjad, Mubeen, Muhammad, Karuppannan, Shankar, 2022).

Raji *et al*. (2014), greater population along the riverbank and river inundation in southwest Nigeria's lower portion of the Lavun worsen floods. According to Tripathi et al. (2020); Amee and Rabeena (2022), Niger State experiences yearly water issues during the wet season, which call for immediate attention. Consequently, the mapping of the floodplain in Lavun is needed in order to reduce and manage the yearly flood occurrences.

The Study Area

This section provides a detailed description of the topography of the study region based on its location, climate, flora, soil kinds, drainage, and population.

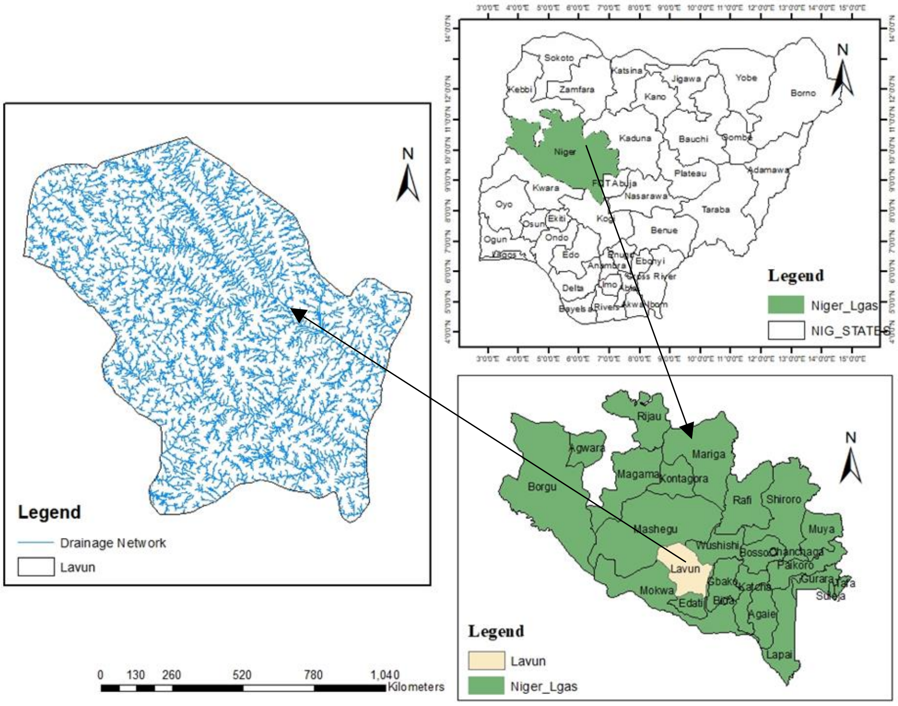


Figure 1: The study area

Geographically, Lavun is bounded by 50° 36' 00''E to 50° 50' 00''E and 90° 12' 00''N to 90° 10' 00''N. Kutigi village serves as its governing hub (Figure 1). According to the 2006 census, it has a 2,835 km^2 area and 209,917 inhabitants (National Population Commission, 2006). Tanko et al. (2012) noted that the primary occupations of the bulk of the people in these societies' western boundaries are farming (crop and cattle rearing) and fishing in the River Kaduna using canoes and local fishnets.

Materials and Methods

The materials that were acquired to achieve the above objective were:

(i) Digital Elevation Dataset from Shuttle Radar Topographical Mission (SRTM).
(ii) Germin 76 Global Positioning System for acquisition of spatial locations of some communities in Niger State
(iii) Thematic map of Niger State
(iv) The 2006 Population and Housing Census Data
(v) ArcGIS 10.3 and CorelDraw 12 software

Methods

Generation and Classifications of Digital Elevation Models (DEM) of Niger State Since the study dwells much on terrain analysis, the terrain of the state was achieved through the generation of DEM images of the state (Ebinne, Elijah, and Ojima Isaac Apeh 2019).

The DEM creation module of ArcGIS 10.3 was used to create the DEM of Niger State from Digital Elevation Dataset of Shuttle Radar Topographical Mission (SRTM). The SRTM3 was used which has a spatial resolution of 90m. The acquired dataset was vectorized using the raster polygon module of ArcGIS, while the output polygon map was classified into four major classes of:

(i) River Kaduna floodplain/basin which lies on heights between 0 and 172m above the sea level and was classified as "highly vulnerable" to flood
(ii) The plain with heights ranging from 172-267m above sea level which was classified as "vulnerable" to flood.
(iii) The upland areas with a range of 267-382m above sea level was classified as "marginally vulnerable"
(vi) The highland areas with their heights between 383 and 744m (the highest point in the state) above sea level as "not vulnerable" (Fig.4).

Creation of Buffer along the River Kaduna in Lavun LGA

When the spillways of the Shiroro dam are opened, the land on both banks of the River Kaduna is impacted by an average of five kilometers of water, but by an average of ten kilometers when there are excessive floods. Using the numerous buffer modules of ArcGIS software, buffer zones of 5 and 10 kilometers were created on the Kaduna River south of the Shiroro Dam. Due to the significant amount of water discharged from the dam, particularly when the spillways are opened, the height of the highland regions nearby Shiroro Dam may also be severely impacted by floods on both sides.

Linking of Some Communities to the DEM and the Buffer Zone Map

In order to connect some chosen communities to the appropriate locations in the state, the coordinates of the towns were obtained using the Germin 72 Hand- Held Global Positioning System (GPS). The following criteria were used to choose the towns that were connected to the map:

1. In the Lavun LGA, ten (10) communities were chosen from those near the Kaduna River's bank. Depending on their proximity, the communities were picked at random. By using hand-held GPS to determine the coordinates of each of the 10 locations of the chosen communities and adding those coordinates to the map using the ArcGIS "add x, y data" tool, it was possible to determine the precise locations of all the communities. The goal of this process was to be able to pinpoint the communities that are located in each of the two safety zones, which are 5 and 10 kilometers in length. The data shown in Figure 3.2 and Table 3.1 was then found and created using ArcGIS' software.

2. The DEM map was linked to the 10 communities that were chosen from among the many communities along the River Kaduna valleys downstream of the Shiroro dam in Lavun LGA. However, a random selection method was used due to the expense and effort involved in getting the coordinates of every village in Lavun LGA.

3. The flood risk map of Lavun LGA was classified using the following criteria on the generated DEM and buffer maps, with the LGA border lines superimposed on the DEM map: Every village along the Niger and Kaduna River basins within a 3- and 5-kilometer buffer is anticipated to be more susceptible to flooding than communities along the Niger and Kaduna River valleys within a 5- and 10-kilometer buffer, respectively.

Floodplain Vulnerability Map

A flood vulnerability map was generated from the generated DEM map and the locations of the communities. The flood vulnerability of the terrain and the communities based on their locations was classified into the following categories:

1. Highly vulnerable: All the land and communities within the 3 and 5 buffer zones on the Kaduna River, downstream of Shiroro Dam.
2. Vulnerable: All the land and communities located in the plains, as well as those within a 5- and 10-kilometer buffer along the River Kaduna in Lavun LGA.
3. Marginally vulnerable: all the land and communities located in the upland areas of the terrain.
4. Not vulnerable: All the land and communities located in the highland areas are not vulnerable.

2.3.1. Development of Geo-database and Spatial Query

The chosen communities along the River Kaduna basin in the Lavun LGA were entered into a database. The database was then searched to produce some data that could be used in the decision-making process. All the communities within a 5 km buffer along the River Kaduna, all the communities within a 10 km buffer along the River Kaduna, and finally all the communities located in the study area's floodplain were queried using ArcGIS' attribute module (Adewuyi, 2014; Ojigi, Abdulkadri, and Aderoju, 2013; Okoye, Chidinma, and Vincent, 2015).

Results and Discussions

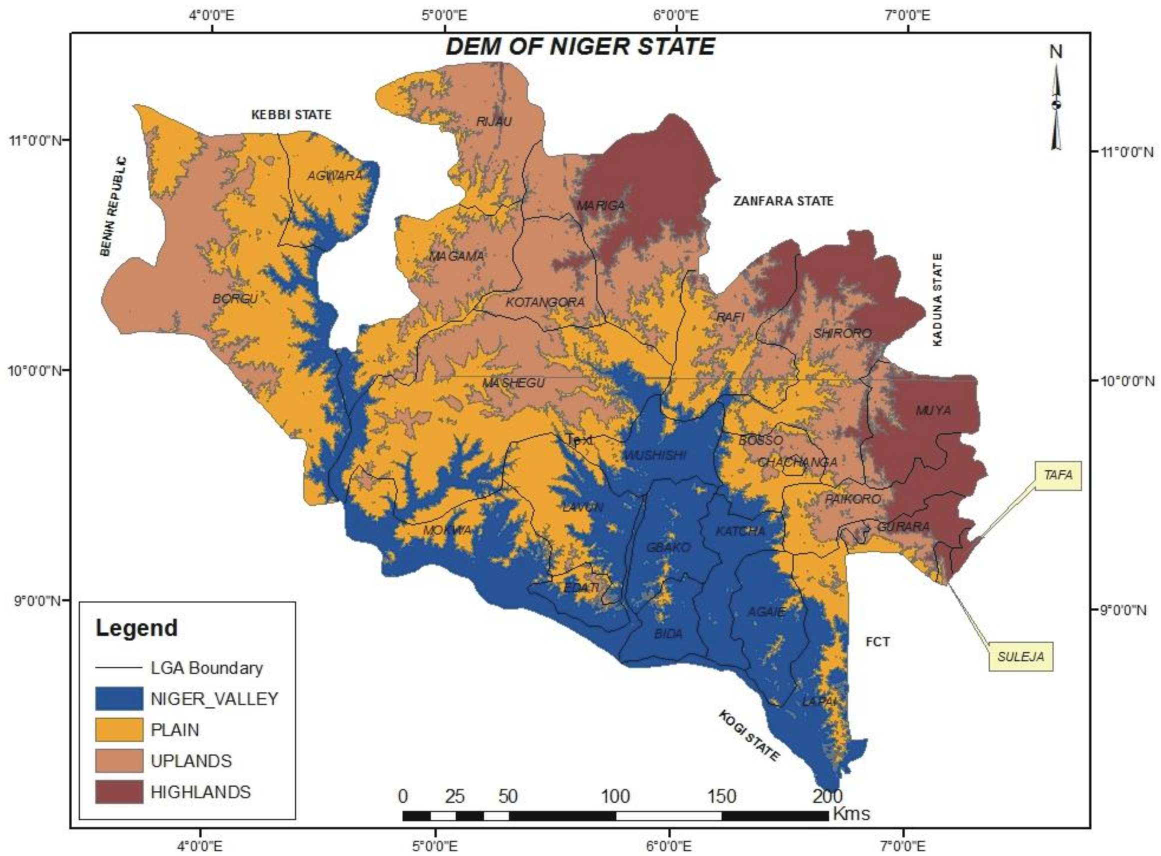


Figure 6: DEM of Niger State
Source: Ikusemoran, *et al*., (2014)

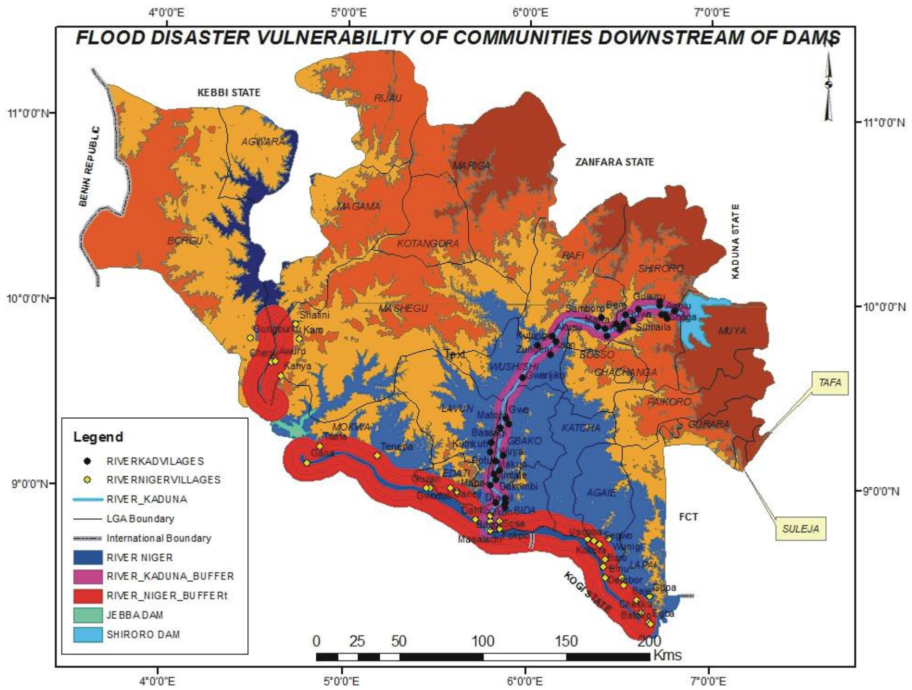


Figure 7: Communities' vulnerability to flood disaster in Niger State

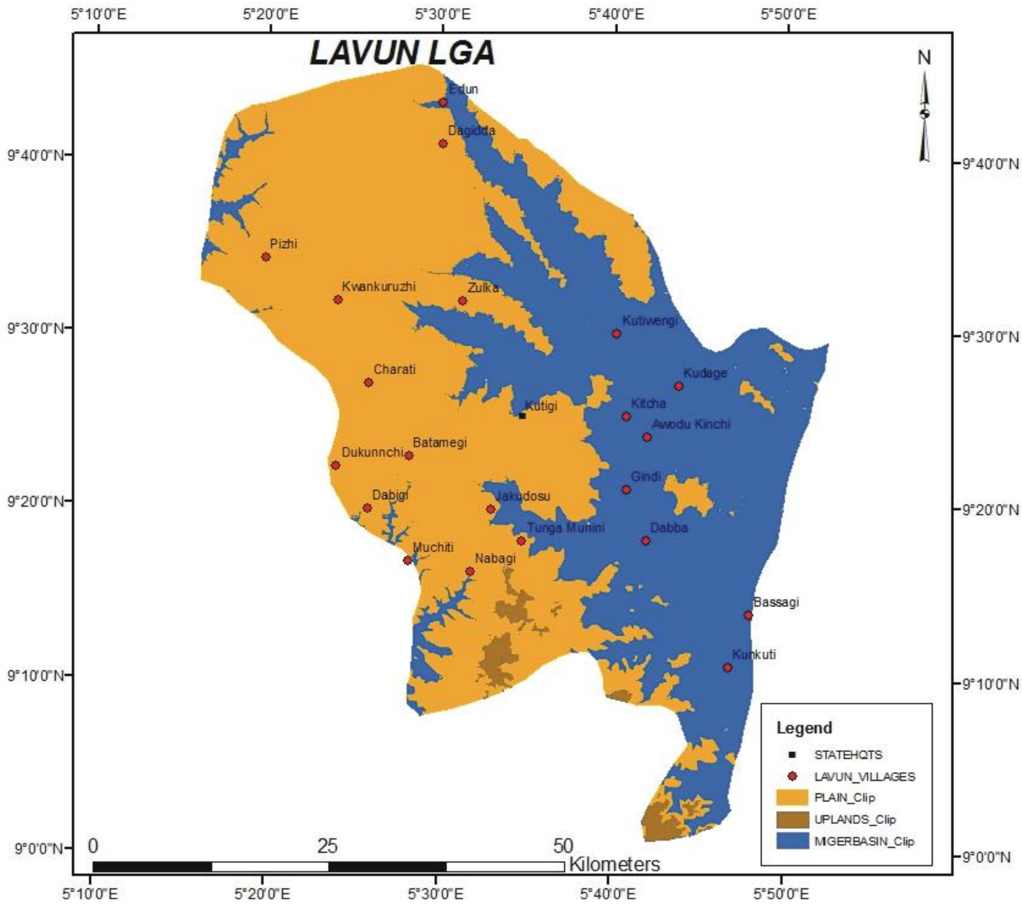


Figure 8: Locations of some communities on DEM showing Extent of the Floodplains of River Kaduna in Lavun LGA, Niger State.

Source: Author's Laboratory work, (2022).

Table 16: Floodplain analysis and categorization of Lavun LGA

S/No	Terrains	Heights (m)	Areas square Km	Percentage%	Volunerability
1.	Low Lands	0-172	707.049	24.94	Highly vulnerable
2.	Floodplains	172-267	1346.625	47.50	Vulnerable floodplain
3.	Uplands	267-382	434.6055	15.33	Marginally vulnerable
4.	Highlands	382-744	346.7205	12.23	Not vulnerable
	TOTAL		2835	100	

Source: Laboratory work Analysis, (2022)

From Table 1, as corroborated by Ojigi, and Shaba, (2012), the following were deduced:

(i) River Kaduna floodplain/basin which lies on heights between 0 and 172m above the sea level and was classified as "highly vulnerable" to flood (707.049sqkm).

(ii) The plain with heights ranging from 172-267m above sea level was classified as "vulnerable" to flood (1346.625sqkm)

(iii) The upland areas with a range of 267-382m above sea level was classified as "marginally vulnerable" (434.6055sqkm)

(vii) The highland areas with their heights between 383 and 744m (the highest point in the state) above sea level as "not vulnerable" (346.72 sqkm) (Fig.3).

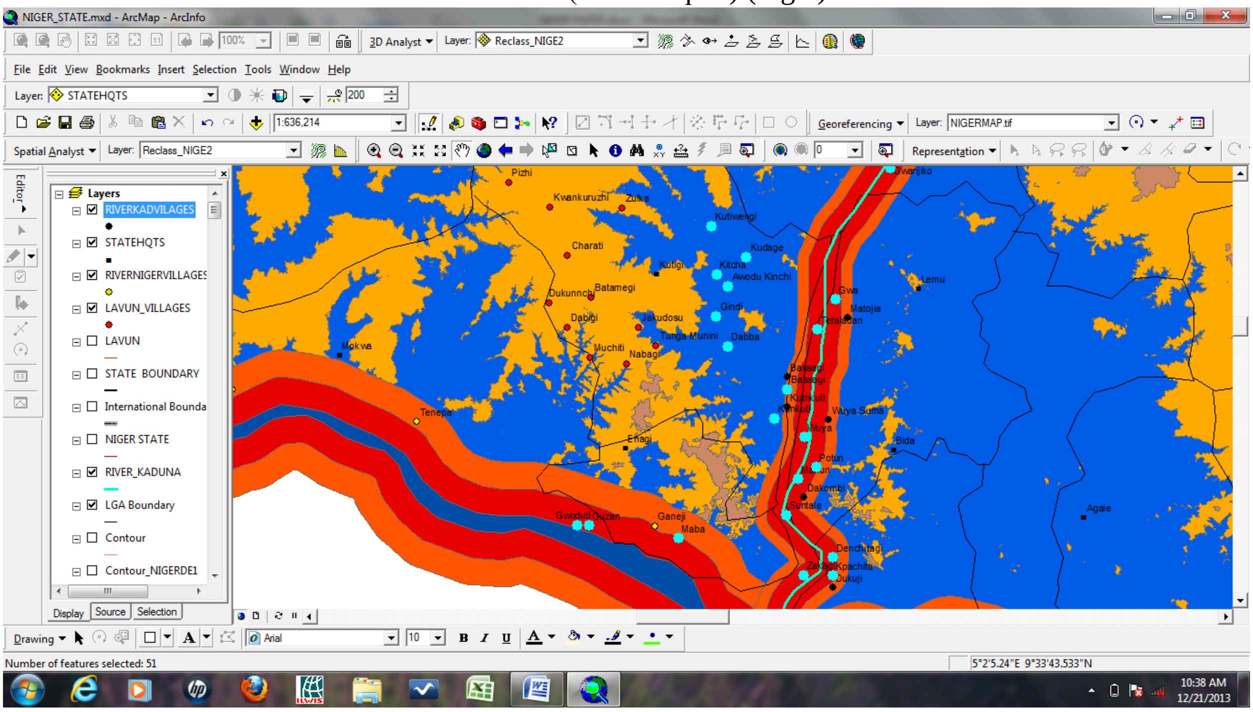


Figure 9: Assessment of the communities with highly vulnerable terrain

Ground Validation of results.

Ground validation will be required to ascertain the precision and reliability of the findings in order to identify the reliability of the results received from the research region. In order to evaluate how rainfall data interacts with other themes, such as elevation and drainage, for the creation of a map of flood-prone regions, rainfall data was transformed into attribute data and used during GIS editing and overlay operations.

The maps of Niger State were changed to digital format so the scholar could compile the required information for the study. The maps were digitized using ArcGIS 10.3 along with other required ArcView 3.2 application extension software tools, such as Image Analyst and Spatial Analyst, with help from the GIS center at the Federal University of Technology, Minna, Nigeria. Overlay analysis is just one of the GIS modification techniques used in this research.

Using the available point junctions, the physical occurrences on the map were compared positively to the satellite images of Lavun supplied by Google (2020). The digitization and overlay studies carried out on traditional maps also resulted in a margin of error for the GIS software used that varies from 1 to 10%.

The modelled zones' points and ground-level inundation spots were contrasted. These sample locations were labeled, and then the correlation coefficient was used to evaluate them. According to the findings of the correlation study, the model's output had a coefficient of 0.8196 and a standard error of 0.48 in comparison to the ground inundation points. This outcome demonstrated the flood model's dependability because it closely matched the ground flood locations.

Conclusion

Lavun LGA's floodplain was mapped using remotely observed data and GIS methods in order to determine how susceptible the study region is to flooding disasters. According to the study, Pizhi, Dagidda, Zulka, Gindi, and Dabigi Dabba are "vulnerable" communities, while Bassagi and Kutokuti's topography (10 km buffer) is extremely susceptible. These communities are situated on the River Kaduna floodplain, which is more populated than the nearby upland and highland areas because it is suitable for crop cultivation and has year-round pastures for animals to graze, particularly during the dry season.

The annual floods brought on by spill-water from dams across the Niger and Kaduna rivers along the Niger-Benue trough have threatened the survival of the locals here for a number of decades, which made the creation of the Hydroelectricity Power Producing Areas Development Commission all the more necessary (HPPPADEC).

Based on the study's results, the following suggestions are made to successfully reduce the effects of the flood disaster in the research area's floodplains: Automated mapping and analysis of the terrain of the Lavun LGA to create a data bank and a master plan for flood disaster monitoring and management in the LGA; creation of comprehensive data and periodic reviews of all the communities that are vulnerable to flooding in the study for quick decision-making, especially during flood disasters; relocation of all the communities that are discovered to be highly vulnerable to flooding; and dissuasion of future flood disasters.

REFERENCES

Abiodun Daniel Olabode, L. T. (2014). Analysis of Flood Risk Zones (Frzs) Around Asa River in Ilorin Using Geographic Information System (GIS). International Journal of Innovative Science, Engineering & Technology, 621-622.

Adewuyi, U. (2014). A survey of the area vulnerable to flood and mitigationstrategies, adopted by Akare community, Niger State, Nigeria. UnpublishedProject submitted to the department of Disaster Risk Management and Development Studies, Federal University of Technology Minna Niger State, Nigeria.

Anyanwu, A. (2015). Assessment of Flood Vulnerability of Abia State, using GIS. Unpublished Master's Degree dissertation. Department of Geography and National Resources Management. University of Uyo.

Bronstert, A. (2013). Floods and Climate Change: Interactions and Impacts.Risk Analysis, 23(3): 11-19.

Ebinne, Elijah, And Ojima Isaac Apeh. 2019. "Satellite-Based Flood Mapping for Impact Assessments: A Case Study in Lokoja, Kogi State, Nigeria Satellite-Based Flood Mapping for Impact Assessments: A Case Study In Lokoja, Kogi State," No. July.

Etuonovbe, Angela Kesiena. 2011. "The Devastating Effect of Flooding in Nigeria The Devastating Effect of Flooding In Nigeria," No. May: 18–22.

Gwaram et al (2014). Climate Change: Its Implications on Food Security and Environmental Safety. Biological and Environmental sciences. Journal for the Tropics 1 (2).

Karki, S., A. Shrestha, M. Bhattarai, And S. Thapa. 2011. "GIS Based Flood Hazard Mapping and Vulnerability Assessment of People Due to Climate Change: A Case Study from Kankai.

Ikusemoran Mayomi, Anthony Dami and Maryah, A.U. 2013. GIS based assessment of flood risk and vulnerability in the Benue floodplains, Adamawa State, Nigeria. Journal of geography and geology, Vol.5 No.4. pp 148-160.

Raji, Adekunle S, Shakirudeen Odunuga, And Usman 2014 Khalil. 2014. "Flood Frequency Analysis and Inundation Mapping of Lower Ogun River Basin Flood Frequency Analysis and Inundation Mapping of Lower Ogun River Basin.

Tripathi, Gaurav, Arvind Chandra Pandey, Bikash Ranjan Parida, And Amit Kumar. 2020. "Flood Inundation Mapping and Impact Assessment Using Multi-Temporal Optical and SAR Satellite Data A Case Study Of 2017 Flood in Darbhanga District," Water Resources Management. Watershed, East Nepal." Development, No. June. Doi:10.13140/RG.2.1.4993.2965.

Analysis of Urban Growth Monitoring and Indicator-Based Assessment Using Remote Sensing Technique in Abuja Nigeria

Umar, I.A.[1a] & Etim, E.E.[1b]
Department of Surveying and Geoinformatics, Federal University of Technology Minna Nigeria.
aliyuibrahimu@yahoo.com; geoetim@gmail.com
Correspondence author's email: aliyuibrahimu@yahoo.com

Abstract:

The population of Abuja City has risen by 31.16% since the year 2000. One of the consequences of urbanization is transformation of land cover from rural/natural environments to impervious surfaces that support diverse forms of human activity. The aim is to investigate the extent of urbanization in the capital city of Nigeria. The analyses are based on performance of classifications methods of optical satellite imagery at medium to high spatial resolutions (i.e., Landsat TM/ETM+, SPOT-1/5, Sentinel-2A MSI and QuickBird-2/WorldView-2) Various classification techniques (maximum likelihood under urban/rural masks, object-based image analysis with rule-based or support vector machine classifiers) were studied with combinations of spectral, shape and textural input features to obtain high accuracy classifications. Environmental indicators such as landscape metrics, urbanization indices, buffer/edge/proximity analysis, and ecosystem service valuation and provision bundle as well as habitat connectivity were also calculated based on the classifications and used to estimate environmental impact of urbanization. The study shows that the land cover in between the different times showed significant change. Between 1999-2014 and 2014-2022, Built-up has continuously increased from 138414m2 to 1945347m2 with a percentage growth of 1.43% to 20.26%. This study reveals that NP continuously increased throughout the period of study where in 1999, NP was 2632, 2014 was 8813 and 2022 had 9828. This shows that the landscape gets more fragmented and heterogeneous as the urban continuously increased

Keywords: Urbanization, Remote Sensing, Land-cover Classification, Environmental Impact

Introduction

Urbanization is a global phenomenon, it shows no sign of slowing down, could be the most powerful and invisible anthropogenic force that has brought about fundamental changes in land cover and landscape pattern around the globe. Rapid urbanization and urban growth, especially in the developing world continues to be one the crucial issues of global warming in the 21st century affecting physical dimensions of cities (Abebe, 2013). Some of the most dynamic places on planet Earth are urbanized locations developing across multiple dimensions.

The use of remote sensing at medium resolution to monitor biodiversity has seen extensive development in recent years (Pettorelli et al. 2014b). Mairota et al. (2015) highlight the high-resolution data that remote sensing can deliver on habitat quantity and quality but note hindrances that have limited its use for this purpose. Boyle et al. (2014) demonstrate the utility of high-resolution optical remotely sensed data for monitoring land-cover change for conservation but also found that its use was very limited (approximately 10% of the land-cover studies used satellite imagery of 5 m or less in the research published by three major conservation biology journals). By evaluating changes in landscape patterns and environmental impact of urban growth in different regions and at different scales, the results highlight data, methodological approaches and indicators likely to be useful for urban and environmental assessment and planning in many different locations.

Problem Statement

Urbanization poses numerous challenges for those working towards sustainable development. While cities may experience internal problems as they grow, their impact on the surrounding natural environment upon which they depend is of critical importance. The city of Abuja over the years had been witnessing unprecedented population explosion due to its status as the current capital city of Nigeria and also its strategic location in the centre of the country (see Table 1).

Table 17: Population statistics of Municipalities in Abuja year 2006

Municipality Name	No of Inhabitants Population	No of Households Units
Abuja Municipal (AMAC)	1,176,298	188,093
Abaji	58,642	10,572
Bwari	229,274	51,797
Gwagwalada	158,618	33,196
Kuje	97,233	17,696
Kwali	86,174	15,206
Total	1,406,239	316,560
Mean	234,373.20	52,760

As the seat power in Nigeria, many activities are going, ranging from economic, physical and structural developments are constantly on the increase. This makes Abuja the state capital as the centre of attraction to these activities. As a result of this, dramatic transformation of the urban land which affects other land cover has been going on over past few decades. The pressure to grab land for physical development by individuals and corporate organizations has been on the increase bringing about springing of sub-urbans around the federal capital territory. These uncontrolled urban developments tend to abuse the recommended planning rules laid down for any physical infrastructural development.

Objectives

i. To map out the various land use land cover classes

ii. To analyse the magnitude of change within the different land use land cover classes over the period of study

iii. To evaluate some selected landscape metrics and their effects on urban space in the study location.

Study Area

The study area, also known as the FCC, falls within the FCT occupying approximately 400 km2. It is located in the center of Nigeria between 7°20' and 9°15' North of the Equator and longitudes 6°45' and 7°39' East (Figure 1).

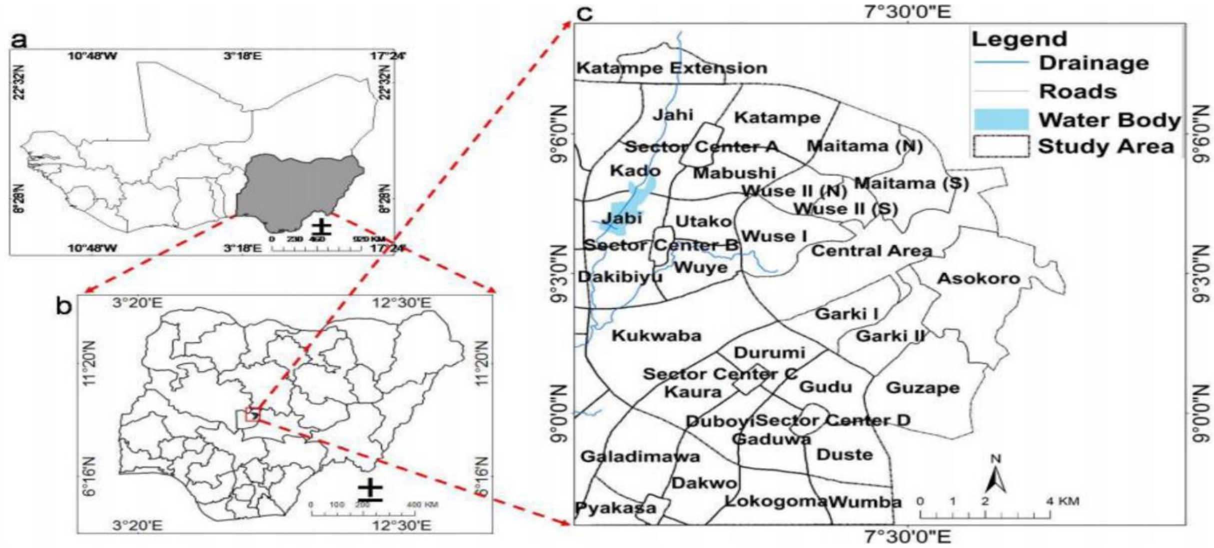


Figure 10: Map of Study area (a) West Africa inset Nigeria; (b) Nigeria inset Federal Capital City (FCT) and Abuja city in red rectangle and (c) Zoom of Abuja City showing major districts.

In the tropics under the Koppen climate classification, Abuja features a tropical wet and dry climate thereby experiencing three weather conditions annually. This includes a warm, hu-mid rainy season and an intense dry season. The rainy season begins in April and ends in October. There is a brief interlude of harmattan occasioned by the northeast trade wind, with the main features being dust haze and dryness. This begins in November and lasts until January/February. The topography, high altitudes and undulating terrain of the FCT act as a moderating influence on the weather of the territory. Rainfall in the FCT reflects the territory's location on the windward side of the Jos Plateau and as a zone of rising air masses. The annual total rainfall is in the range of 1100-1600 mm.

Methodology

The processes involved in this research are captured in the flowchart shown in Figure 2 below for easy comprehension.

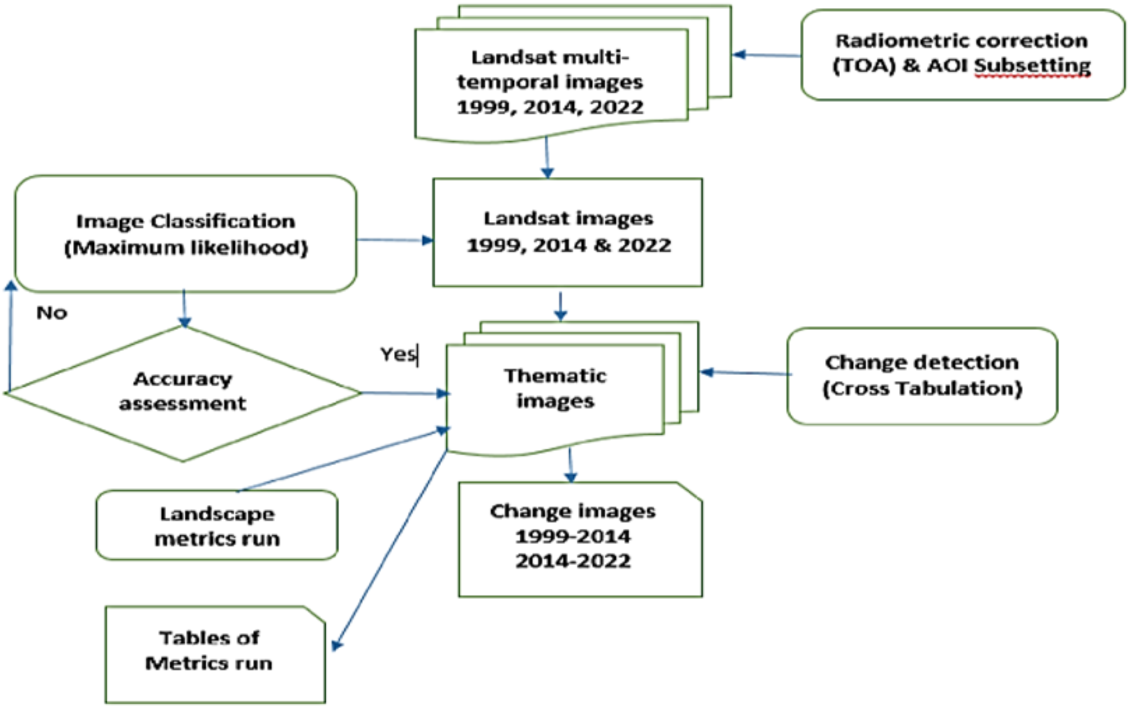


Figure 11: Flowchart of Methodology

Data Collection

Office work

Downloading of Landsat satellite images

Landsat images dated 17/1/1999 (Landsat 5 TM), 16/1/2014 Landsat 8 OLI) and 15/2/2022 (Landsat 8 OLI) with path/row 189/054 was downloaded from the United States Geological Survey (USGS) website.

Field work

This involved acquiring GPS positional data on LULC representative samples for the purpose of ground truthing during image classification.

Atmospheric effects in optical remote sensing are significant and complex, dramatically altering the spectral nature of the radiation reaching the remote sensor. The objective is to determine the true reflectance values by removing atmospheric effects from satellite images. This the most important part of the pre-processing of satellite remotely sensed data.

Convert digital number (DN) values to top of atmosphere (TOA) reflectance.

This was performed by carrying out radiometric calibration (RC) on the MTL multispectral file. BSQ was selected as output interleave at scale 1.00 and the out-data type as float. The output file name was given as Refectance_1999.

Convert TOA reflectance to surface reflectance (SR) by dark object subtraction (DOS).

The dark subtraction module was lunched from the toolbox menu. The reflectance_1999 file created above was selected as input data. In the dark subtraction parameter dialogue box, an output file name was entered as Darksub_1999 and the run button was activated.

The shape file of the area of interest (ROI) was used to subset all the Landsat images. This vector file of the study area (ROI) was obtained from the shape files of administrative map. The clip tool in ArcGIS 10.3 was used to crop area of interest for this research.

Results and Presentation

The LULC thematic maps provides further insights about land use/ land cover change trends and rates. The results reveal land use/ land cover change history and quantity of change in each LULC class. The landscape went through three different stages (years 1999, 2014 and 2022), with each map representing a different stage, and each stage dominated by different land use/ land cover activities (Figs. 5, 6 and 7). The main land uses in the area in the first stage (represented by the 1999 map) was Vegetation (89.58%) followed by Bare surface (9.84%). Built-up (0.43%) and finally water body (0.14%) see figure 11 and Table 8. In the year 2014, Vegetation still dominated the land cover space by (.90.18%) followed by Bare surface even though there was a reduction to (7.49%). Built-up was able to move up to (1.87%) and finally water body also increased to (0.44%) as shown in Figure 10 and Table 7. The situation in 2022 also shows that Vegetation still dominated the land cover by (58.99%) which is an indication of massive decrease followed Built-up with a tremendous increase in development expansion of (22.02%). Bare surface also had an increase in land cover space of (12.45%) while water body continuously increased to (6.52%) as shown in Figure 9 and Table 6. The classification accuracy of the Landsat images for the three epochs as shown in Table 9 shows that 1999 had a kappa statistic of 86.72%, 2014 image classification returned a value of 82.42% while in 2022, a kappa value of 83.20% was obtained. The chart in Figure 12 shows at a glance the overall situation of the study area where vegetation continuously shows a decrease throughout the period of study, Built-up on the other hand continually increased alongside water body while the bare surface had an inconsistent movement. Table 11 is the change matrix of Land area change of all the themes considered. Between 1999 and 2014, Water body and Built-up experienced an upward increased of 28508m2 and 138416m2 respectively. While vegetation and Bare surface witnessed a decreased as -5809m2 and 232150m2 respectively. The chart in Figure 13 shows the pictorial situation of the study area as the various themes display their behaviour over the period of study. Table 12 is a holistic situation of land use land cover change situation based on percentage. Built-up had 1.43% in 1999-2014, 20.25% between 2014 and 2022 and with an overall percentage increase of 21.59% from 1999 to 2022. Vegetation continually decreased throughout the study period with an overall percentage decreased of -30.81%. Water body on the other hand continue to increase steadily to the point of having an overall increase of 6.37% while bare surface in 1999 to 2014 reduced to -2.39% and had an increase in 2014-2022 to about 5.01% but steadily rose to 2.58%.

The change matrix of Land area changes of all the themes considered. Between 1999 and 2014, Water body and Built-up experienced an upward increased of 28508m2 and 138416m2 respectively. While vegetation and Bare surface witnessed a decreased as -5809m2 and 232150m2 respectively. The chart in Figure 13 shows the pictorial situation of the study area as the various themes display their behaviour over the period of study. Table 12 is a holistic situation of land use land cover change situation based on percentage. Built-up had 1.43% in 1999-2014, 20.25% between 2014 and 2022 and with an overall percentage increase of 21.59% from 1999 to 2022. Vegetation continually decreased throughout the study period with an overall percentage decreased of -30.81%. Water body on the other hand continue to increase steadily to the point of having an overall increase of 6.37% while bare surface in 1999 to 2014 reduced to -2.39% and had an increase in 2014-2022 to about 5.01% but steadily rose to 2.58%.

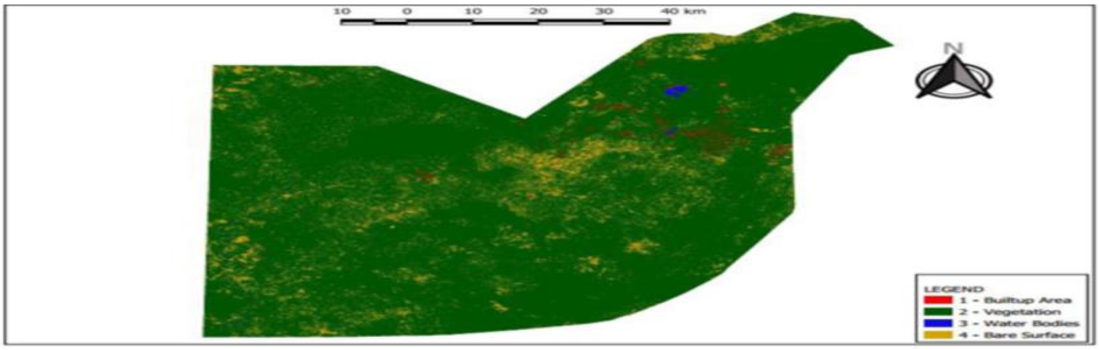


Figure 5. LULC classification of 1999

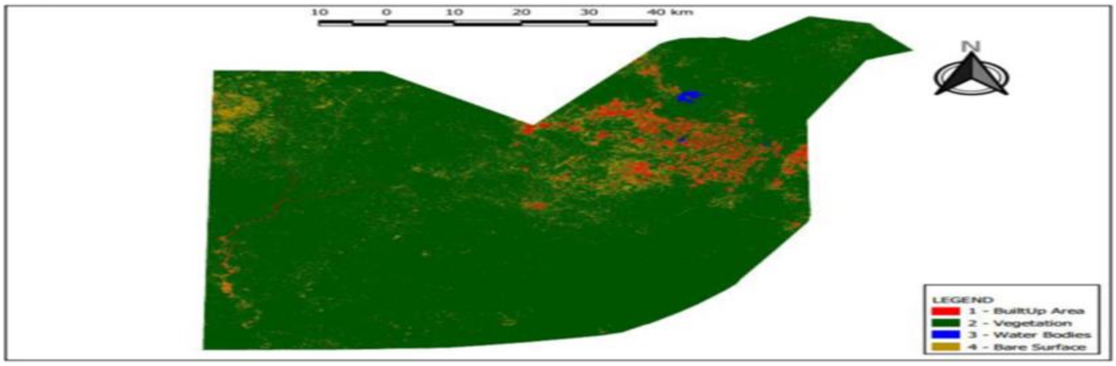


Figure 12: LULC Classification of 1999

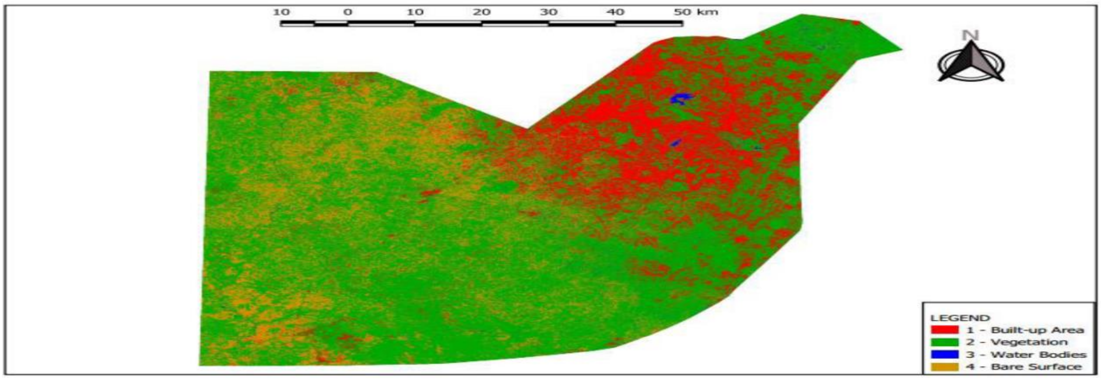


Figure 7. LULC classification 2022

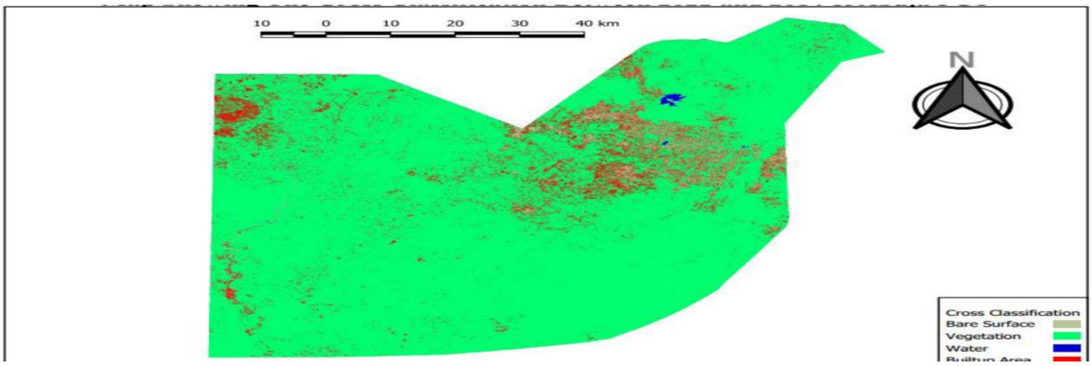


Figure 13: Cross Tabulation map

Table 18: 2022 report of classification

2022 Report			
Class	PixelSum	Area [metre^2]	Percentage %
Builtup Area	1355857190	2125276	22.02642953
Vegetation	4564940179	5692493	58.99718243

Water Bodies	10125000	629355	6.522655671
Bare Surface	525172500	1201630	12.45373237
Total	6456094869	9648754	100

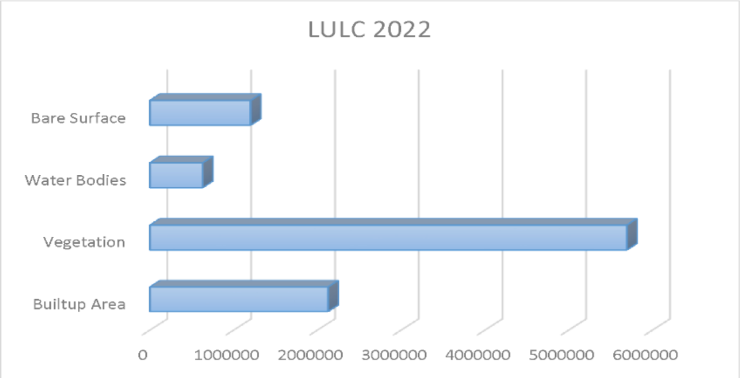


Figure 14: Chart showing LULC distribution of 2022

Table 19: 2014 Report of Classification

2014 Report			
Class	PixelSum	Area [metreA2]	Percentage %
Builtup Area	144476100	179929	1.873736746
Vegetation	6890778000	8659920	90.18229593
Water Bodies	3800647342	42948	0.447250003
Bare Surface	1609892789	719886	7.496717324
Total	12445794231	9602683	100

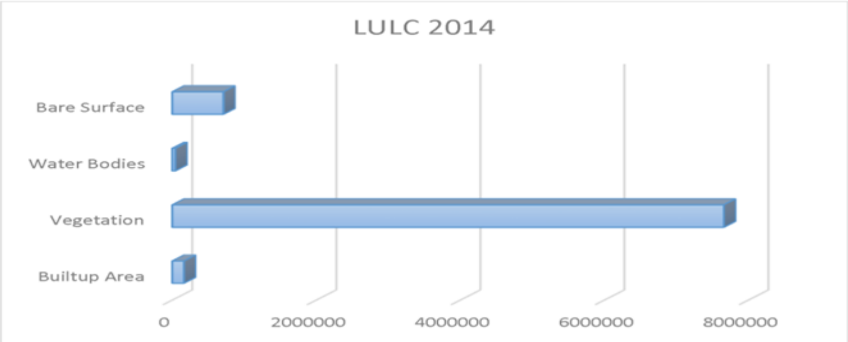


Figure 15: Chart showing LULC distribution of 2014

Table 20: 1999 report of classification

1999 Report			
Class	PixelSum Area [metreA2]		Percentage %
Builtup Area	37361700	41513	0.429131798
Vegetation	6882399900	8665729	89.58012834
Water Bodies	12984300	14440	0.149270425
Bare Surface	637727400	952036	9.841469433
Total	7570473300.00	9673718	100

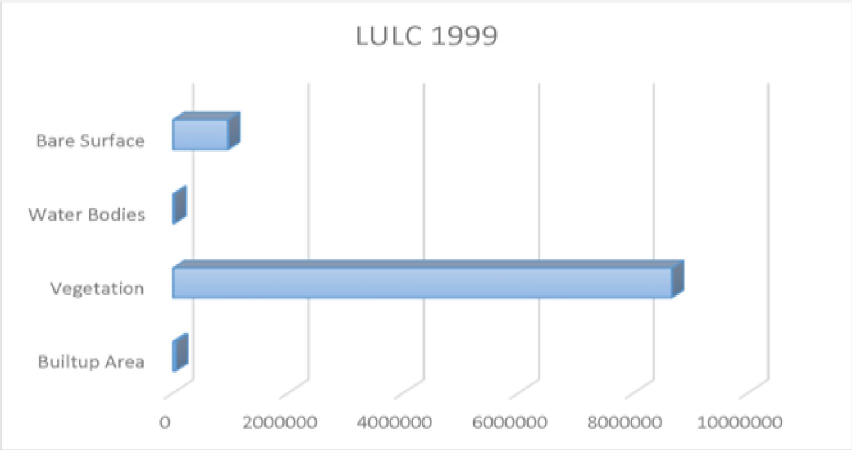


Figure 16: LULC Distribution of 1999

Overall Classification Accuracy Overall Kappa Statistics

Table 21: Accuracy assessment for the classified images Reference Year Classified image

1999	Landsat	TM	86.72%	0.7478
2014	Landsat	OLI	82.42%	0.8863
2022	Landsat	OLI	83.20%	0.8060

Table 22: LULU Area Distribution

	2022 (m^2)	2014 (m^2)	1999 (m^2)
Builtup Area	2125276	179929	41513
Vegetation	5692493	8659920	8665729
Water Bodies	629355	42948	14440
Bare Surface	1201630	719886	952036

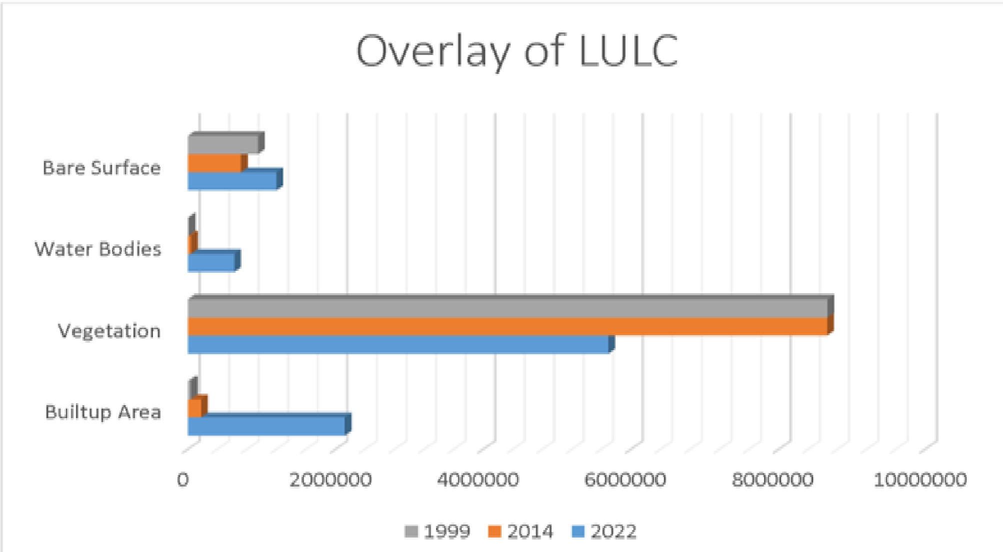


Figure 17:Overlay of LULC

Table 23: LULC area change

	2022-1999 (mA2)	2022-2014 (mA2)	2014-1999 (mA2)
Builtup Area	2083763	1945347	138416
Vegetation	-2973236	-2967427	-5809
Water Bodies	614915	586407	28508
Bare Surface	249594	481744	-232150

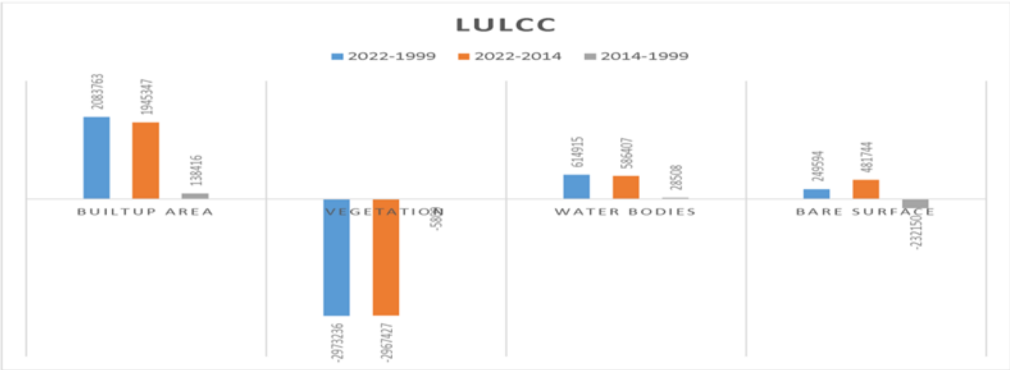


Figure 18: Chart showing LULC change

Conclusion

This study has demonstrated the role of satellite remote sensing and Spatial Metrics in producing accurate LU/LC maps and change statistics of the study area in the past 23 years between 1999 and 2022. In the study area, similar study has not been carried out to quantify and detects the changes and patterns of the urban growth. It is worth mentioning that Fichera et al (2012) tried to examine the major causes and consequences of the expansion Abuja, infrastructure, and population data. This work was different in approaches and techniques to test the role of geospatial tools in the urban Land cover change detection of Abuja. The study shows that the land cover in between the different times showed significant change. Between 1999-2014 and 2014-2022, Built-up has continuously increased from 138414m2 to 1945347m2 with a percentage growth of 1.43% to 20.26%. Vegetation with an area decreased from -5809m2 to and -2967427m2 while a percentage decreased of -0.06% to -30.90% within the time periods of study.

Landscape change has been experienced in the recent past are likely to continue. More studies to document the expected impacts of these changes are needed. These future analysis studies are recommended to use more detailed socio-environmental variables to improve the understanding of the causes, locations, and trends of land use changes in the study area. Understanding how the changes in the landscape and climate change might influence the distribution of landscape variables as well as wildlife and other environmental factors will help guide conservation planning in the area. The study can serve as guidelines for other studies attempt to project LULC change in Abuja and environs experiencing similar land use changes.

References

Abebe, G. A (2013). Quantifying urban growth pattern in developing countries using remote and spatial metrics. A case study in Kampala, Uganda. MSc thesis submitted to the faculty of Geo-information science university of Twente, Netherlands

UNFPA (2008) (http://www.unfpa.org/swp/2007/english/introduction.html (last visit Nov,2020).

Estimation of Leaf Area Index using geospatial methods-A review

Oleh, T.C.[1] & Ajayi, O.G.[2]
[1]Department of Surveying and Geoinformatics, Federal University of Technology, Minna,
[2]Department of Land and Spatial Sciences, Namibia University of Sciences and Technology, Windhoek, Namibia
infotheosol@yahoo.com; gbenga.ajayi@futminna.edu.ng
correspondence email: infotheosol@yahoo.com

***Abstract**:*

Leaf Area Index (LAI) is an essential vegetation leaf structure parameter for forest and agricultural ecosystems which can be estimated using different means. Remote sensing (RS) methods provide cost-effective alternatives to conventional field-based methods for LAI estimation. This paper presents the concept of LAI and methods for its estimation, with specific emphasis on geospatial methods. It also reviewed the concept of image classification in LAI estimation and the most commonly used image classification algorithms, which include random forest, supervised vector machine, artificial neural network, Bayesian, CARS-SPA, boosting, genetic, lookup tables, K-nearest neighbour, and modified K-nearest neighbour, while also highlighting some current research issues associated with LAI estimation from remotely sensed data. The findings of the study suggested that LAI can be accurately estimated from UAV imagery and that random forest, modified KNN, and conventional KNN algorithms are the most suitable classification algorithms for accurate LAI estimation using a remote sensing approach, especially when UAV images are used. The need for considering data science techniques for validation of the image classification approach for LAI estimation was recommended.

Keywords: Leaf Area Index, Classification, Algorithms, Geospatial Techniques, Forest Canopy.

INTRODUCTION

The scientific and efficient estimation of Leaf Area Index (LAI) is of significance for the evaluation of plant growth potential, as well as providing reliable technical support for the optimization of field management practices. The LAI used for determining forests, crops, climate, and soil is expressed as half the area of all leaves per unit area of the ground (Huan et al. 2022) LAI is a one-sided measure of leaf tissue per square inch of soil (Watson, 1947). A plant with a LAI of two (2) has the number of leaves that covers a given area twice. Different models use LAI to estimate fluxes between soil, canopy, and land-surface regions, and they do so in meters square (m2) (Bréada 2003). LAI can be estimated using either direct or indirect methods. The direct method of LAI estimation involves the physical measurement of leaf area within a particular area of interest which often requires destructive or allometric tree defoliation. This rigid procedure makes it difficult to apply the direct method or technique to large-scale studies and only suitable for the calibration of indirect methods (Bréada, 2003; Jonckheere et al. 2004). The direct method includes the clipping method which involves the collection of a sample of leaves from a plant canopy, and the measurement of their leaf area in a laboratory using a leaf area meter. The LAI is then calculated by dividing the total leaf area by the area of the ground sampled. Another method is the Point quadrat method which involves a device that is held at a fixed height above the canopy and has needles that randomly touch the leaves. The number of hits per unit area is recorded and used to estimate the LAI. The integrating sphere method is also a direct LAI estimation method that involves placing a plant inside a spherical chamber and measuring the light transmission through the chamber. The LAI is then calculated based on the amount of light that is absorbed by the leaves.

On the other hand, indirect method of LAI estimation involves the use of other parameters that are related to LAI, such as canopy reflectance, transmittance, or vegetation indices. These methods include: hemispherical photography, Light Detection and Ranging (LiDAR) which uses laser pulses to measure the distance between the sensor and the top of the canopy. The data can then be used to create a 3D image of the canopy, which can be used to estimate LAI, and spectral indices. The indirect method of LAI estimation is faster, easier, and automated, making it suitable for large geographic applications. The cost of indirect methods and the need for well trained personnel is the limitation of this method (Jonckheere et al. 2004).

Photogrammetry is one of the indirect, spatial based approaches to LAI estimation that uses a minimum of two (2) images of a spatial area to obtain three (3) dimensional (3D) information about the said area, which can be obtained by using information such as camera position, focal length, etc. Photogrammetry's primary purpose is to make use of two-dimensional images (2D) at different locations and re-produce into three-dimensional (3D) models of the same location. Recently, unmanned aerial vehicles (UAVs) have risen to prominence as a veritable photogrammetric method due to their cost-effectiveness in data collection and a high resolution compared to those from satellites and aircraft (Muhammad et al., 2020). The UAV photogrammetric process includes a remotely piloted aerial vehicle, a sensor payload, UAV flight planning, establishing and preparing ground control points (GCPs), check points (CPs), image processing with appropriate software, and map production and analysis as it relates to mapping projects (Muhammad et al. 2020). UAVs have proven to be reliable tool for the acquisition of spatial data and the extraction of geospatial data, such as LAI and image classification is one of the methods for extracting geospatial data from image-based spatial data.

Image classification assigns spectral classes to data classes. Spectral classes are groups of pixels that are similar in terms of their brightness values across the various spectral channels of data. An analyst can identify information classes in the image based on his knowledge and experience of the subject. For example, a remotely sensed image contains spectral signatures of many features that are present on the ground in terms of pixels of different values. When generating a thematic map, an interpreter or analyst sorts homogeneous groups of pixels with similar values and labels them as information classes such as water, agriculture, forest, etc. However, different spectral classes can be combined in one data class. Image classification consists of three main categories: supervised, unsupervised, and object-based image classification. Spectral signatures are unique, allowing one object to distinguish the other, which is the basis of classification in remote sensing, and they enable the extraction of LAI from remotely sensed data (Anupam and Krishna, 2012).

Some Image Classification Algorithms used for LAI Estimation

There are numerous image classification algorithms in use for the estimation of LAI but only a few of such algorithms for LAI estimation are discussed in this article. Table 1 presents the summary of the characteristics of the ten (10) selected image classification algorithms used predominantly for LAI estimation. The choice of these selected algorithms is informed by their frequency of use or implementation and their characteristics (Pirotti et al. 2016).

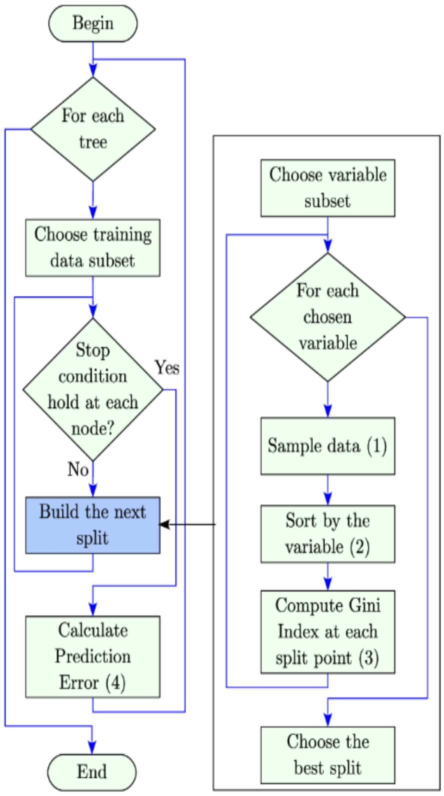
GEOSPATIAL METHODS OF LAI ESTIMATION

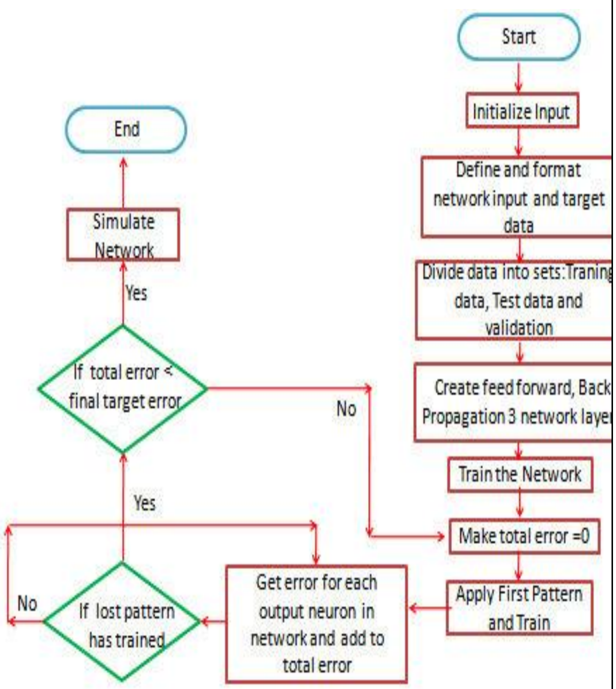
1. Direct measurement methods: It provides the most accurate LAI assessment and it is used for the evaluation of indirect remote sensing methods. It is laborious and less popular. Litterfall and biomass harvesting are examples of direct measurement (Beeck et al. 2019).

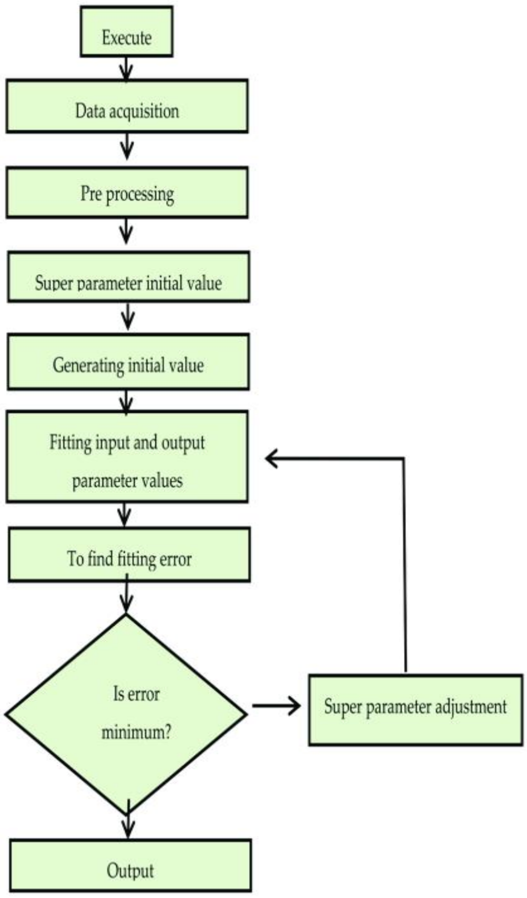
a. Litter fall: Deciduous plants lose their leaves annually; they carry same area as their annual leaf litter. Some leaves will fall mid-year before the canopy's maximum number of leaves forms It measures every area of leaf littered, this is one of the most accurate LAI methods. Meanwhile some of the littered leaves may blow away thereby reducing LAI measurement accuracy.

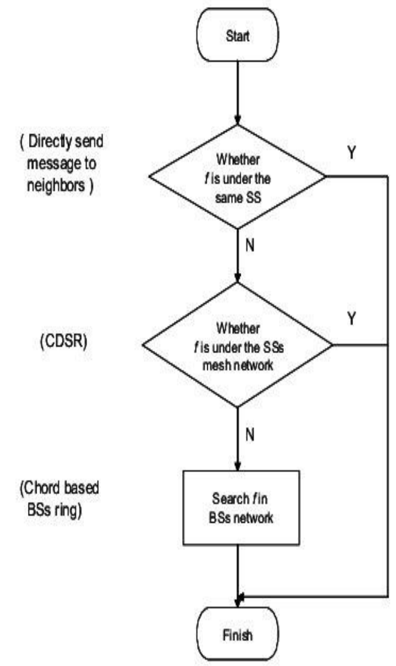
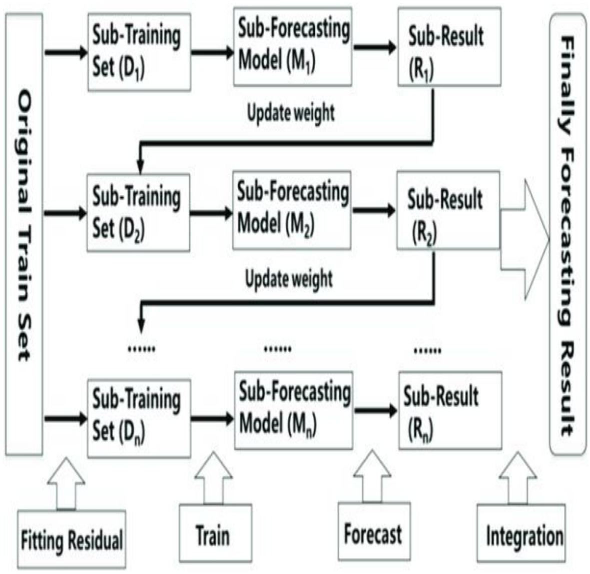
b. Biomass harvesting: It could measure leaf or needle area if LAI from a particular year was impossible. This is the most accurate but hardest way to estimate LAI for evergreen conifers. Stem area index calculates canopy woody element surface area (SAI). This destructive method affects no other plot measurements. This destructive method is the most accurate at estimating LAI, but it is rarely used unless it is the only option.

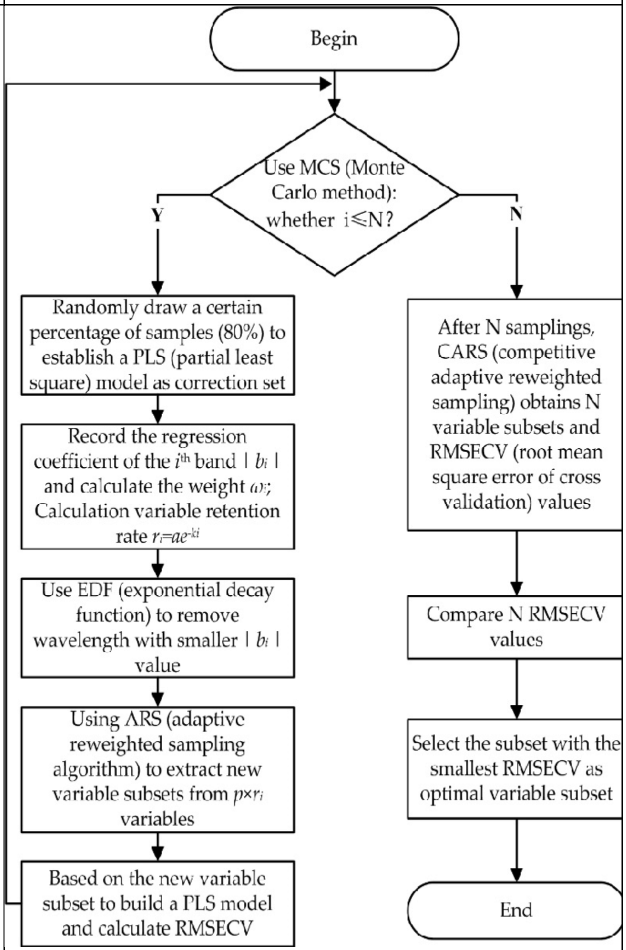
Table 1: Characteristics of selected image classification Algorithms.

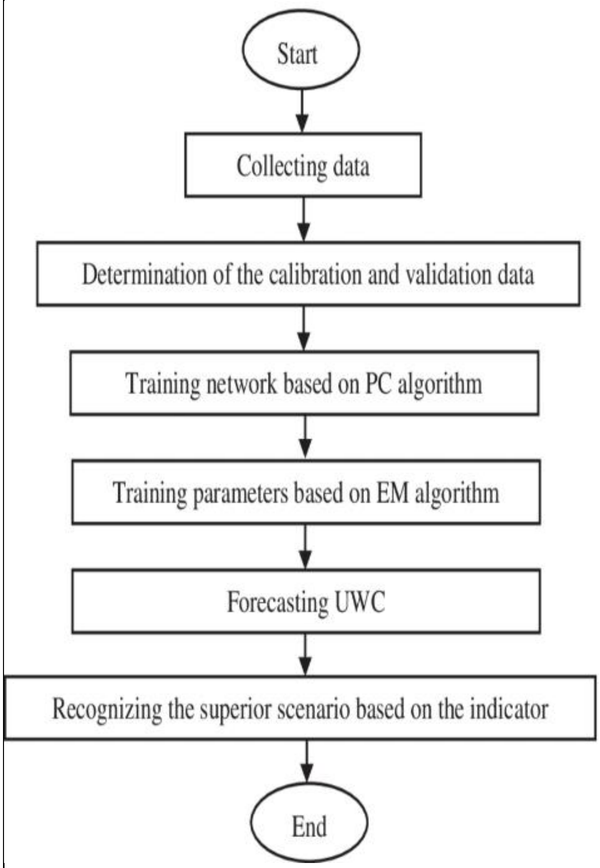
Image classification algorithms	References	Characteristics	Mathematical Formulation	Flow Chart Presentation of Process
Random Forest Algorithm (RFA).	Patel et al. (2019), Shuguo et al. (2020), Breiman, (2001).	-On large datasets, this set of facts is useful. - It can handle thousands of input variables without deleting anyone. - It estimates variables that are essential in image classification. -It generates a forests dataset that can be retrieved for future use (Breiman, 2001).	Given a training set X = x1, ..., xn with responses Y = y1, ..., yn, bagging repeatedly (B times) selects a random sample with replacement of the training set and fits trees to these samples: For b = 1, ..., B: Sample, with replacement, n training examples from X, Y; call these Xb, Yb. Train a classification or regression tree fb on Xb, Yb. After training, predictions for unseen samples x' can be made by averaging the predictions from all the individual regression trees on x': $$\hat{f} = \frac{1}{B}\sum_{b=1}^{B} f_b(x')$$ where $\hat{f}$ is the predictive estimation of the model.	 Source: Balli et al. (2019)

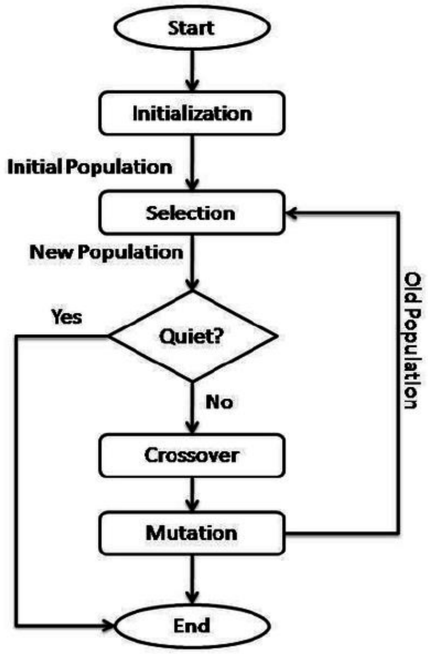
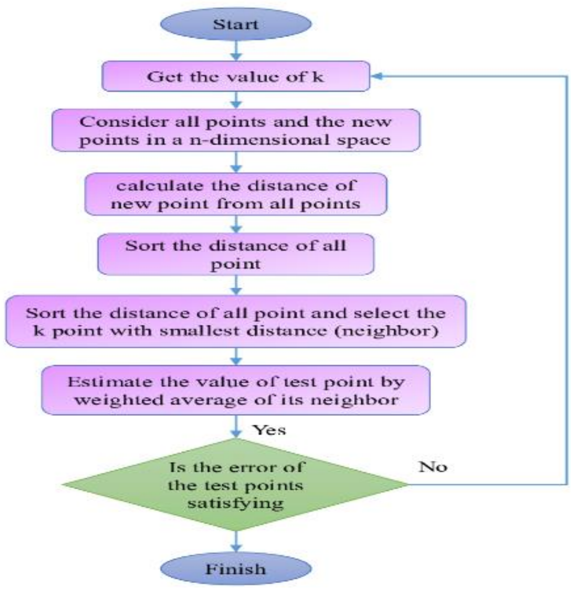
Artificial Neural Network (ANN).	Shunlin and Hongliang (2003), Zhang et al. (2011)	-For nonlinear systems dynamic findings and simulations, ANN has robust information modelling techniques that are used in a variety of ways. - Because of the ability to do approximation in a universal form and simple pattern, it allows the capture of complex nonlinear behaviour. - AN is also being used for research purposes (Nagy, 2007).	Building a neural net F so that ideally $F\left(x^{(i)}\right) = t^{(i)}$ where $x^{(i)}$ represent networks in neural net. However, typically we allow for error ϵ_i. Let $y^{(i)}$ denote the output of the neural net so that: $y^{(i)} = F(x^{(i)})$ and $t^{(i)} = y^{(i)} + \vec{\epsilon}_i$ We know that $y^{(i)}$depends on parameters, which are weights and biases, then it turns out as an optimization problem. We need to set up a neural net F that minimizes the error function, which is denoted below: $E = \frac{1}{N}\sum_{i=1}^{P}\left\Vert t^{(i)} - y^{(i)}\right\Vert^2$ where N is the number of training patterns and E is the error function.	 Source: Li et al. (2015).

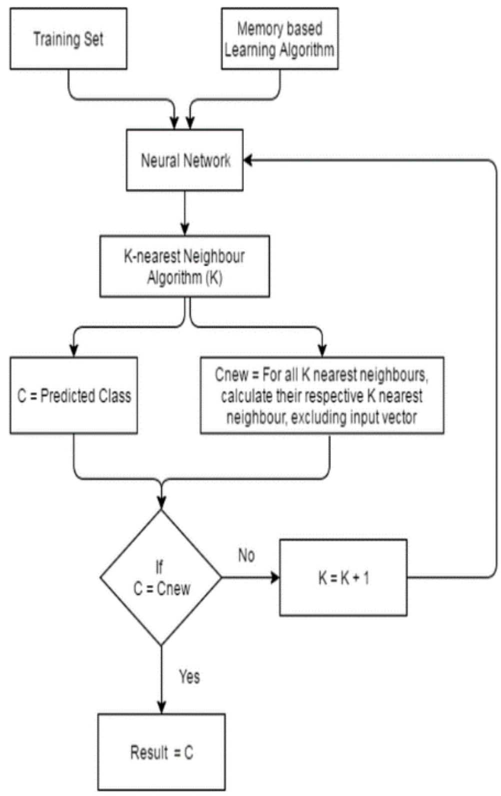
Support Vector Machines	Surya et al. (2006), Suthaharan and Suthaharan (2016).	-It uses hyperplanes to segment data that have been mapped to higher dimensions. - The information is mapped using a kernel. As it pertains to the data, various kernels are used. (Cortes and Vapnik, 1995).	Some mathematical kernel functions which you can use in SVM are given below: Polynomial kernel: $f(x_1, x_2) = (x_1^T.x_2 + 1)^d$. Here d is the degree of the polynomial, which we need to specify manually. Sigmoid kernel: We can use it as the proxy for neural networks. Equation is: $(x_1, x_2) = tanh(\propto x^T.y + x)$. It is just taking your input, and maps them to a value of 0 and 1 so that they can be separated by a simple straight line. RBF kernel is the most used kernel in SVM classifications, and it is depicted mathematically as follows: $f(x_1, x_2) = \frac{-\lVert x_1 - x_2 \rVert^2}{2\sigma^2}$, $f(x_1, x_2) = e$. where, 1. 'σ' is the variance and our hyperparameter 2. $\lVert x_1 - x_2 \rVert$ is the Euclidean Distance between two points x_1 and x_2. Another kernel is the Bessel function kernel: It is mainly used for eliminating the cross term in mathematical functions. Following is the formula of the Bessel function kernel: $k(x, y) = \frac{J_{v+1}(\sigma\lVert x-y \rVert)}{\lVert x-y \rVert^{-n(v+1)}}$. Finally, ANOVA Kernel performs well on multidimensional regression problems. The formula for this kernel function is: $k(x, y) = \sum_{k=1}^{n} exp\left(-\sigma(x^k - y^k)^2\right)^d$	 Source: Suthaharan and Suthaharan (2016)

Lookup Table Algorithm	Feng et al. (2006), Abebe (2006), Zhang et al. (1999)	LUTs are not used to creatively grade result, but rather they are used to make up a difference between a source and a result. (Friesen, 2011).	The mathematical representation provides a closed-form formula that allows us to compute the precise Lookup Table sizes for each Lookup Table transformation to minimize solution error as: $$S_i = CS \Big/ \left(\sum_{j=1\ldots n} \sqrt{(M_j D_j / M_i D_i)} \right)$$ $$E_i = M_i D_i \left(\sum_{j=1\ldots n} \sqrt{(M_j D_j / M_i D_i)} \right) / CS$$ Where: S_i: Estimation precise Lookup Table sizes E_i: Estimation solution error.	 Source: Gong et al. (2012).
Boosting	Shunlin et al. (2003), Huihui et al. (2019), Alzubi (2016).	-Boosting involves those algorithms that detects weaker learning classifiers when it comes to distribution and applying the same to the final stronger classifier. -When added to the final strong classifier, it is usually weighed in some ways, as it usually refers to weaker	([illegible] unction L: R2 → R, the gradient boosting algorithm iteratively constructs a model F:X→R to minimize the empirical risk ED[L(f(x),y)]. x, y ϵ X ϵ L , for L is a real number. At each iteration time (t), the model is updated as: $F^{(t)}(x) = F^{(t-1)}(x) + \varepsilon h^{(t)}(x)$. where $F^{(t)}(x)$ is estimated parameter of the model and $h^{(t)}(x)$ is a weak learner chosen from some family of functions.	

		learners' precision (Freund and Schapire, 1996).		Source: Alzubi (2016).
Competitive Adaptive Reweighted Sampling Projection Algorithm (CARS-SPA Algorithm)	Tang et al. (2014).	- It was first used in the selection of descriptive variables and SPA model it has minimal redundant data.	The use of CARS method begin with use of Monte Carlo method for sampling which can be represented mathematically given x- random variable at the random point in the interval [a,b], then $x_i = a + \sum_{k=1}^{n}(b-a)$. Secondly the Partial least squares method modelling is to decompose X and Y as follows $$X = TP^T + E$$ $$Y = UQ^T + F$$ In the formula, $T$and U are score matrices. P and Q are load matrices corresponding to X and Y respectively. E and F are residual matrixes. The relationship was established using Y =Tc +e = WXc + e = Xb + e. Where e is the prediction error, and b = Wc = $[b_1\ b_2 \ldots\ b_p]$is p-dimensional coefficient vector. $$r_i = ae^{-ki}$$ Where a and k are two constants. In the first sampling, all p variables are used for modeling, which means $r_1 = 1$. In the Nth sampling, only two variables are kept, so we get $r_N = {}^2/_p$. Under these two conditions, a and k can be calculated as: $a = \left({}^2/_p\right)^{1/(N-1)}$, k= $\frac{\ln({}^2/_p)}{N-1}$, where ln represents the natural logarithm	 Source: Tang et al. (2014)

Bayesian Network Algorithm.	Terry et al. (2004), Jochem et al. (2015), liang et al. (2020).	- This is a joint probability distribution of a set of random variables with a potential mutual association. - It consists of nodes that represent random variables, edges between pairs of nodes that represent the nodes relationship and a conditional probability distribution within the nodes. - When observing new data, it models a posterior conditional probability distribution of the outcome variable(s) (Michal Horny, 2014).	The Bayesian Network Algorithm as the background from the framework of probabilities, you say that you have a prior distribution P(A), and next you wish to compute the posterior P(A | b). considering certain belief in the state of a particular variable, A. Next you receive the information that the state of the variable B is b, and you wish to use this information to update your belief in the state of A. For a Bayesian network exploiting the conditional independencies in causal networks, we get: Let CN be a causal network over U = {A1 , . . . , An}. Then P(U) has the following factorization: $$P(U) = \prod_{i=1}^{n} P\,[A_i \vert pa(A_i)]$$ The factorization above is the background for the concept Bayesian networks.	 Source: Sun et al. (2006)

Genetic Algorithm	Abraham et al. (2021), (Jenna, 2014)	- GA's are programming techniques that used to find the most efficient solution(s) to a given computational problem that maximizes or minimizes a particular function. - They are more effective than random search and complex search algorithms (Jenna, 2014).	Since genetic algorithms are designed to simulate a biological process, much of the relevant terminology is borrowed from biology. However, the entities that this terminology refers to in genetic algorithms are much simpler than their biological counterparts. The fitness function is the function that the algorithm is trying to optimize. If a problem has Npar -dimensions, then typically each chromosome is encoded as an Npar-element array chromosome = = [p1, p2, ..., pNpar]. The fitter a chromosome is, the more likely it is to be selected then the f is a non-negative fitness function, then the probability that a particular chromosome C is chosen to reproduce might be: $$P(C) = \left\| \frac{f(C)}{\sum_{i=1}^{N_{pop}} f(C_i)} \right\|$$	 Source: Lambora et al. (2019).
K-nearest neighbor (KNN) algorithm.	Mykola et al. (2020), (Samworth, 2012).	-It applies kernel functions in weighting neighbours with varying distances, so that not only kernel functions but also every monotonic decreasing function will work (Samworth, 2012).	The k-nearest neighbor classifier fundamentally relies on a distance metric. The better that metric reflects label similarity, the better the classified will be. It can be represented mathematically as: $$d(x, y) = \sqrt{\sum_{i=1}^{n} (x_i - y_i)^2}$$ Hence, function d(x,y) denote the classified estimation of metric at a distance point xi and yi.	 Source: Xiong and Yao (2021)

Modified K-nearest neighbour (MKNN) algorithm	Parvin et al. (2008), Mykola et al, (2020).	-It employs a kind of preprocessing on train data -It adds a new value called validity to train samples. -The validity takes into account the value of stability and robustness of any train sample regarding with its neighbors -Applying the weighted KNN employs validity as a multiplication factor yields a more robust classification.	The modified K-nearest neighbour (MKNN) can be represented mathematically $$d(x,y) = \sqrt{\sum_{i=1}^{n}(x_i - y_i)^2}$$ 2nd Step: Validity of Training Data $$\text{Validity} = \frac{1}{K}\sum_{i=1}^{K} S\left(\lvert b\rvert(x), \lvert b\rvert\left(N_{i(x)}\right)\right)$$ The S function is used to calculate the similarity between point x and the i-th data from the nearest, where a and b ∈ x. neighbor as follows: $$S(a,b) = \begin{cases} 1_{a=b} \\ 0_{a \neq b} \end{cases}$$ 3rd Step: Weight Voting $$W(x) = validalitas(x)x\frac{1}{d_{e+0.5}}$$	 Source: Sahu et al. (2018).

2. Indirect optical measurement methods: These methods measure light penetration through the canopy in the foliated stage and calculate the leaf area needed to produce the observed light above-under canopy relationship. Measurement systems struggle with penetration rates of about 5% with a leaf area index of six. Hemispherical photography, plant canopy analyzer, and sunscan ceptometer are some examples (Beeck et al. 2019).

a. Hemisherical photography: Hemispherical photography (fisheye or canopy photography) measures potential solar radiation and describes the plant canopy at 180 degrees. Since indirect optical methods estimate LAI, photographs have the highest-resolution optical data. The canopy images can measure canopy architecture metrics like gap fraction, sunfleck timing and duration, and others. They can be archived and re-analyzed as methods and software improve.

b. The plant canopy analyzer LAI-2000: Small hemispherical lenses detect light above and below the canopy. It uses the blue channel of the spectrum (320nm – 490nm), where the contrast between leaves and sky is greatest, and a second sensor to measure light above the canopy. This indirect optical method thrives in low light conditions and is not recommended for use in areas of very high sun light intensity, even though it is an efficient LAI estimation method. This method cannot measure LAI in humid conditions or when there is little or no sunlight.

C. The SunScan ceptometer: It uses high amount of direct light and is made possible by two sensors simultaneously above and below the canopy. It is one of many ceptometers available today, and it has been included to represent LAI measurements with ceptometers. The major strength of this method lies in its potential of measuring LAI accurately especially with the use of two (2) sensors above and below the canopy on a high intensity of sunlight. Thus, the main limitation is the inability to be used in poor atmospheric weather conditions like humid temperature, with little or no sunlight.

d. Airborne LiDAR: Airborne LiDAR is an indirect optical method. Knowing the time of light emission and the speed of light enhance the measurement outcome, backscattered data is used to determine the exact 3D position and other information about the reflecting material. Airborne LiDar is best for large areas from several square kilometres to entire regions, but it is expensive. LiDAR data provides a very accurate data for indirect LAI estimation (Bharat and Suddhasheel, 2017).

e. Unmanned Aerial Systems and satellite imageries: These involves gathering information about a place, object, or region without physical contact. This method accurately and cost-effectively calculates LAI by preparing their images, analysing and evaluating with algorithms. The main drawbacks of this method are low-resolution satellites, poor image analysis, and a lack of high-resolution sensors for UAV flights, especially in agriculture. Poor weather affects satellite and UAV reliability (Muhammad et al. 2020).

CONCLUDING REMARKS AND FUTURE OUTLOOK

Biophysical parameters like LAI predict stable agricultural growth and food availability in a long run. This review has provided concise information on LAI estimation with emphasis on its two basic approaches, while also presenting clear information on image classification algorithms and geospatial techniques that are used for estimating LAI. The review result shows that literature on LAI estimation concentrated on the indirect approach while validating the obtained results with direct methods. This direct method, which is invasive, still poses great threat to the healthiness and sustainability of plants because of the need to pluck off the leaves in the process of LAI estimation. Despite the rate of acceptance of data science techniques for validation of data experiments, little or no research has considered the approach for validation in LAI estimation. This method will not only provide accurate and reliable LAI estimation, but will ensure that the biophysical states of the leaves are not altered in the process of doing so. This will be the focus of our research in the near future.

REFERENCE

Abebe M. A. (2006). Retrieving Leaf Area Index of a Mature Norway Spruce Forest Stand From airborne Hyperspectral Image by inversion of the Dart Model. Thesis submitted in partial fulfillment of the degree of Master of Science in Geo-Information Science at Wageningen University and Research Centre, The Netherlands.

Abraham M., Francesca C., Giovanni C., Giacomo F., Eugenia C., Simonetta P., Mattia R., Emanuele S., Deodato T. and Claudia N. (2021). Biomass retrieval based on genetic algorithm feature selection and support vector regression in Alpine grassland using ground-based hyperspectral and Sentinel-1 SAR data. DOI: 10.1080/22797254.2021.1901063

Alzubi, J. A. (2016). Diversity-based boosting algorithm. International Journal of Advanced Computer Science and Applications 7(5):524 DOI:10.14569/IJACSA.2016.070570

Anupam A. and Krishna B. (2012). Processing and Classification of Remotely Sensed Images.

Balli, S., Sağbaş, E. A., and Peker, M. (2019). Human activity recognition from smart watch sensor data using a hybrid of principal component analysis and random forest algorithm. Measurement and Control - London- Institute of Measurement and Control- 52(3):002029401881369 DOI:10.1177/0020294018813692

Beeck M ,Carricondo c, Mauro f, , Roland M, Gielen B, Vitale D, Ceulemans R and Papale D.(2019). A comparison of different methods for assessing leaf area index in four canopy types DOI: 10.2478/forj-2019-0011, http://www.nlcsk.sk/fj/ Volume and Issue: Volume 65, Issue 2. Page range: 67 – 80

Bharat L. and Suddhasheel G. (2017). Airborne LiDAR Technology: A Review of Data Collection and ProcessingSystems. Proceedings of the National Academy of Sciences, India - Section A 87(4). DOI:10.1007/s40010-017-0435-9

Bréada, J. (2003). Ground-based measurements of leaf area index: a review of methods, instruments and current controversies. Journal of Experimental Botany, J Exp Bot. 2003 Nov;54(392):2403-17.doi: 10.1093/jxb/erg263.

Breiman, L. (2001). Random forests. Machine learning, 45(1), 5-32.

Cortes C. and Vapnik V. (1995). Support-Vector Networks. AT and T Labs Holmdel, NJ 07733 USA. Machine Learning, 20, 273-297. http://dx.doi.org/10.1007/BF00994018

Feng D., Jing C., Stephen P., Mingzhen C. and Jan P. (2006) Algorithm for Global Leaf Area Index Retrieval Using Satellite Imagery. IEEE Transactions on Geoscience and Remote Sensing 44(8):2219 – 2229 DOI:10.1109/TGRS.2006.872100

Freund Y. and Schapire R. (2000). Game Theory, On-line Prediction and Boosting. Proceedings of the Nineth Annual Conference on Computational Learning Theory. DOI:10.1145/238061.238163

Friesen J. (2011). What is lookup table (LUT).

Gong, J., Liu, W., and Zhang, H. (2012). Multiple lookup table-based aes encryption algorithm implementation. Physics Procedia 25:842-847 DOI:10.1016/j.phpro.2012.03.166

Huihui M., Jihua M., Fujiang J., Qiankun Z and Huiting F (2019). Comparison of Machine Learning Regression Algorithms for Cotton Leaf Area Index Retrieval Using Sentinel-2 Spectral Bands. Appl. Sci. 2019, 9(7), 1459; https://doi.org/10.3390/app9071459

HuanY., Liping D., Xuan S., Ning W., CaixiaY., WeitongW. and Yun Z. (2022). Estimating leaf area index of maize using UAV-based digital imagery and machine learning methods. www.nature.com/scientificreports | https://doi.org/10.1038/s41598-022-20299-0

Jenna C. (2014). An Introduction to Genetic algorithms.

Jochem V., Gustau C., Jordi M., Juan P., Frank V., Jan G., and José M. (2015). Optical remote sensing and the retrieval of terrestrial vegetation bio-geophysical properties – A review. ISPRS Journal of Photogrammetry and Remote Sensing DOI:10.1016/j.isprsjprs.2015.05.005

Jonckheerea I, Flecka S., Nackaertsa K., Muysa B., Coppina p., Weiss M., and Baretc F. (2004). Review of methods for in situ leaf area index determination Part I. Theories, sensors and hemispherical photography. Agricultural and Forest Meteorology 121(1):37-53 DOI:10.1016/j.agrformet.2003.08.001

Lambora A., Gupta, K., & Chopra, K. (2019). Genetic algorithm-A literature review. In 2019 international conference on machine learning, big data, cloud and parallel computing (COMITCon) DOI:10.1109/COMITCon.2019.8862255

Li, K., Hu, C., Liu, G., and Xue, W. (2015). Building's electricity consumption prediction using optimized artificial neural networks and principal component analysis. Energy and Buildings, Energy and Buildings 108 DOI:10.1016/j.enbuild.2015.09.002

Michal H. (2014) Bayesian Networks. Technical Report No. 5.

Muhammad H., Anuar A. and Qudsia G. (2020). Impact of UAV Surveying Parameters on Mixed Urban Land-use Surface Modelling. International Journal of Geo-Information 9(11):656DOI:10.3390/ijgi9110656

Mykola K., Fugen J., Andrew R., Guangxing W., Hua L., and Hua S. (2020). A Modified KNN Method for Mapping the Leaf Area Index in Arid and Semi-Arid Areas of China pg 1-19. Remote Sensing 12(11):1884 DOI:10.3390/rs12111884

Nagy Z. (2007) Model based control of a yeast fermentation bioreactor using optimally designed artificial neural networks. Chemical engineering journal Vol127, No. 1-3, 95-109. journal ISSN :1385-8947DOI10.1016/j.cej.2006.10.015

Parvin H., Alizadeh H., and Bidgoli B. (2008). MKNN: Modified K-Nearest Neighbor. Proceedings of the World Congress on Engineering and Computer Science WCECS, San Francisco, USA.

Patel N., Subrata N., and Ritika S., (2019) Estimating leaf area index and light extinction coefficient using Random Forest regression algorithm in a tropical moist , India. DOI: 10.1016/j.ecoinf Ecological Informatics Volume 52, Pages 94-102

Pirotti F., Sunar F., and Piragnolo M (2016). Benchmark of machine learning methods for classification of a Sentinel-2 image. doi:10.5194/isprsarchives-XLI-B7-335-2016

Sahu, S. K., Kumar, P., and Singh, A. P. (2018). Modified K-NN algorithm for classification problems with improved accuracy. International Journal of Information Technology 10(3) DOI:10.1007/s41870-017-0058-z

Samworth R. J. (2012). Optimal Weight Nearest Neighbor Classifiers. University of Cambridge. The Annals of Statistics, Vol. 40, No. 5, 2733-2763 (31 pages) DOI:10.1214/12-AOS1049. https://www.jstor.org/stable/41806553

Sedat k., İlker E., Alkan G., and Muammer S. (2018). Artificial neural network models predicting the leaf area index: a case study in pure even-aged Crimean pine forests from Turkey. https://doi.org/10.1186/s40663-018-0149-8

Shuguo W., Liang L., Di G., Juan Y., Siyi Q., Liping D., Lu X., Lijuan W., Jianrong K. and Li L. (2020). Estimating Crop LAI Using Spectral Feature Extraction and the Hybrid Inversion Method. https://doi.org/10.3390/rs12213534

Shunlin L. and Hongliang F. (2003). Retrieving Leaf Area Index with a Neural Network Method: Simulation and Validation. 2052 IEEE Transactions on Geoscience and Remote Sensing 41(9):2052 – 2062 DOI:10.1109/TGRS.2003.813493

Sun, S., Zhang, C., and Yu, G. (2006). A Bayesian network approach to traffic flow forecasting. IEEE Transactions on intelligent transportation systems, 7(1), pp. 124-132. DOI: 10.1109/TITS.2006.869623

Surya S, Roger L and Nicolas H. (2006). Support vector machines regression for retrieval of leaf area index from multiangle imaging spectroradiometer. Remote Sensing of Environment 107 (2007) 348–361

Suthaharan, S., and Suthaharan, S. (2016). Support vector machine. Machine learning models and algorithms for big data classification: thinking with examples for effective learning, 56, p. 207-235. https://doi.org/10.1007/978-1-4899-7641-3_9

Tang, G., Huang, Y., Tian, K., Song, X., Yan, H., Hu, J., and Min, S. (2014). A new spectral variable selection pattern using competitive adaptive reweighted sampling combined with successive projections algorithm. Analyst, 139(19), pp. 4894-4902. DOI: 10.1039/c4an00837e

Terry C., Margret K., Sanchez-Azofeifa G., and Benoit R.(2004). Estimating Leaf Area Index From Satellite Imagery using Bayesian Networks. IEEE Transactions on Geoscience and Remote Sensing 43(8):1866 – 1873 DOI:10.1109/TGRS.2005.848412

Watson J. (1947). Leaf Area Index. Science Direct topics. Background introduction.

Xiong, L., and Yao, Y. (2021). Study on an adaptive thermal comfort model with K-nearest-neighbors (KNN) algorithm. Building and Environment, 202, pp. 108026. DOI 10.1016/j.buildenv.2021.108026

Zhang Y., Myneni R., Knyazikhin Y., Privette J., Running S., Nemani R., Tian Y., Wang Y., JMorisette J., Glassy J,. Lotsch A and Votava P. (1999). MODIS Leaf Area Index (LAI) and Fraction of Photosynthetically Active Radiation Absorbed By Vegetation (FPAR) Product (MOD 15). https://www.researchgate.net/publication/236770186

Zhang Z., Ma X., GuoShun L., Fang J., HongBo Q., Zhang Y., Shizhao L. and WenFeng S. (2011). A study on hyperspectral estimating models of tobacco Leaf Area Index.DOI: 10.5897/AJAR10.533. Advances in Food Science and Technology ISSN: 6732-4215 Vol. 8 (1), pp. 001-007, Available online at www.internationalscholarsjournals.org

Assessment of Climate Change Impact and Population Growth on Concrete Bridges in Minna, Niger State Using GNSS Technology

Ladan, M. D. & Etim. E. E.
Department of Survey and Geoinformatics, Federal University of Technology Minna
[a]macalianx@gmail.com; [b]geoetim@gmail.com
Corresponding author's email: macalianx@gmail.com

Abstract:
Bridges are one of the important infrastructures in the development of the economic and social infrastructure of any country. Climate change may have multifaceted impacts on the safety and performance of bridges, many bridge structures are facing the treat of natural disasters such as earthquakes and floods. The bridges in Minna, Niger state are aging and require urgent assessment in order to protect lives and property. Global Navigation Satellite System (GNSS) positioning technology has had widespread applications in structural health monitoring for the last two decades. However, the use of static observation technique for structural health monitoring is more common due to its high accuracy and reliability but other techniques are yet to be explored. The RTK technique is less time consuming and cost efficient but its data set is susceptible to outliers due to multi-path error during observation. This study presents an approach where time series data is collected for the bridges with an observation epoch of 3months. The outliers within the data sets are isolated using wavelet transform algorithms. The processed datasets were analyzed using Kalman filtering technique. The observation epochs were compared consecutively by finding the difference between successive observation results. The maximum displacement and velocity of displacement for the successive epochs was determined. Then the result was used to produce deformation models and predict the future behavior of the bridges. The kinematic analysis carried out shows that only 1 out of 15 monitoring stations sampled didn't suffer any form of structural deformation during the 12 months of observation at Chanchaga Bridge and 1 out of 5 didn't suffer any form of deformation at Tunga Goro Bridge. It is highly recommended that an alternative route be created to lessen the effort of dense traffic on the two bridges, for now they remain the only access via that axis to minna.

Keywords: *GNSS, RTK, Outliers, Epoch, Kalman Filtering.*

Introduction

Bridges are important infrastructures all over the globe, they facilitate economic and social activities in all countries of the world. Bridges are bearing more load than usual due to increased traffic and with the fast-global climate change; many bridge structures are facing the treat of natural disasters such as earthquakes and floods (Bridge *et al.*, 2018). Bridges are designed to withstand various forces, such as wind, traffic, temperature, tidal current, and extreme loading, for example earthquake, flood, and typhoon (Lewin M, 2019).

These forces are the main factors considered in bridge design and govern in part the bridge's performance and life expectancy. Unlike long-term settlement of bridge foundations, which can be easily monitored with conventional surveying instruments, the dynamic deformation behavior or deflection of bridge has been of concern to civil engineers for many years. Typical examples of dynamic performance in long flexible structures are lateral vibration caused by wind, vertical movement induced by traffic and change of ambient temperature or operating forces in machinery, and accelerating movement immediately preceding the failure of geotechnical structures such as anchorages. (Živanović *et al.*, 2018) In recent years a large number of bridges have incurred damage attributed to impact and fatigue.

In bridge engineering practice, deformation of bridges is considered as a problem that widely exists, there is need for structural health monitoring.

The bridges in Minna, Niger state have aged drastically, mostly built between the late 70s and early 90s. It is highly important to monitor these bridges since no maintenance operation has been carried out since their commissioning and their gross load per day has quadrupled due to the population growth and other economic factors.

For the monitoring of man-made structures, and specifically bridges, it is desirable for the measurement system to deliver equal precision in all position components, all the time.

The GNSS is preferred for Structural health monitoring because it has more benefits than other techniques. GNSS offers advantages over conventional terrestrial methods. Inter-visibility between stations is not strictly necessary, allowing greater flexibility in the selection of station locations than for terrestrial geodetic surveys. (KOK S. K, 2017) Measurements can be carried out during night or day, under varying weather conditions, which makes GNSS measurements economical, especially when multiple receivers can be deployed on the structure during the survey. When using GNSS, the accuracy, availability, reliability and integrity of the position solutions is very dependent on a number of factors. The existence of outliers within GNSS time series data affects the quality of observation therefore, there is need to optimized the data to acquire the required result. Many bridge failures are caused by abnormal loadings. Monitoring the bridge deformation is a vital task in bridge maintenance and management.

Monitoring the bridge displacements by using GNSS has several advantages, which have been discussed by the recent researchers. In stated that GNSS could provide the provision of real-time 3D absolute displacements of engineering structures, continuously autonomous operation under all weather conditions and data acquisition with no need for line of sight between the different stations. Monitoring the bridge deformation using GNSS allow to detect deformation in three-dimensional (3D). Besides that, GNSS also allow for redundant measurements where the precision can be evaluated with a rigorous adjustment. However, GNSS has limited measurement which is redundancy in real-time kinematic positioning mode.

Climate-Change Imposed Risks on Bridges

It is expected that a changing climate will have a negative effect on the degradation of construction materials and accelerate the process. The projected higher temperatures, increased precipitation, and relative humidity in some areas, and higher carbon concentrations in the atmosphere may all contribute to an increased risk of deterioration of bridges.

An Australian study (Stewart, Wang, & Nguyen, 2019) assessed the risk of corrosion in concrete structures in two cities, namely Sydney and Darwin, indicating a possible increase in this risk as an effect of a changing climate. For instance, the study indicates that by the year 2100 the risk of carbonation induced corrosion may increase by more than 400% in some regions. Similar trends are reasonably expected concerning steel bridges. Apart from concrete and steel, a large number of bridges involve timber as a construction material. There is evidence that suggest that these might as well be susceptible to changes in climatic conditions. Floods have always been a cause of concern for the safety of infrastructure, including bridges.

The Effect of Multipath Error on GNSS RTK Data

Multipath propagation means that one or more reflected signals reach the antenna, in addition to the direct signal. It is possible that the antenna only receives the reflected signal under particular circumstances. There can be reflection off horizontal, vertical and inclined surfaces, which can be streets, buildings, waterways, and vehicles. When choosing observation sites, in particular for permanent reference stations, it must be considered. Multipath propagation affects both code and carrier measurements (Zimmermann, F 2018).

Multipath is the error caused by reflected signals entering the front end of the receiving antenna and masking the real correlation peak. In a static receiving antenna near large reflecting surfaces these effects tend to be more pronounced. 15 m or more in ranging error can be found in extreme cases (Parkinson, 2021).

Wavelet Transform for GNSS Data Outlier Detection

Wavelet transforms allow to represent a time series signal in terms of waves (the so-called wavelets) with little local support. While (short-time) Fourier transforms always have a trade-off between accuracy in the frequency domain and accuracy in the time domain, wavelet transforms are used to retrieve accurate time-localized frequency information. The wavelet transform of a time series signal is composed with scaling and shifting functions. They take a mother wavelet and stretch and shrink it (scaling), dilate it along the time axis (shifting), and finally form the scalar product with the time series.

Statement of the Problem

The existence of outliers within GNSS RTK data series makes it difficult to be utilized for the purpose of studying deformation, there is need to optimize the data, reduce multipath error generated by moving vehicles and other GNSS error sources in order to make it eligible for structural health monitoring. The monitored bridges have because weaker due to aging and the effect of climate change, there is need for structural health monitoring in order to ascertain their present condition. There is no available load rating and deformation model for the bridges, there is urgent need to predict their future behavior in order to protect lives and properties.

Aim and Objectives

The aim of the study is to produce kinematic deformation model for the monitored bridges using GNSS RTK time series.

1. To optimize GNSS RTK data for structural health monitoring using wavelet transform.
2. To perform kinematic analysis of the two bridges.

Study Area

The researched bridges are both in Minna Metropolis of Niger State. The area is geographically defined by the parameters of latitude 9^0 32' 17" N to 9^0 31' 27" N and longitude 6^0 27' 21" E to 6^0 26' 18" E

Project Planning

Prior to the GNSS observations, the site was visited to choose suitable controls for reference stations and to mark out the monitoring points along the bridge beam. The monitoring stations were demarcated on top of the bridge and two controls were identified for the purpose of the reseach. A suitable 3month interval observation epoch was selected.

Figure 1: Monitoring stations for bridge A AND B

Methodology

A set of hi target DGPS was used to observe the monitoring stations at different epochs, ranging from epoch 1 to 4. The intervals from the epochs were 3 months. The time series data was fed into the MATLAB script for outlier detection and data optimization using wavelet transform (WT) technique. After the optimization process, the data transformed was used to compute the displacement, velocities and acceleration of movement between epoch 1 to epoch 4 using Microsoft excel functions. Then a MATLAB based Kalman filter was used to predict the bridge behavioral changes for 5 years (20 epoch).

Result

The following results were obtained after 4 epochs of observation on the two bridges. The MATLAB program analyses the average of the multiple observation of each epoch at a monitoring station then adds measurement noise and computes the velocity between different epochs and the time observation to predict the bridge behavior for 5 yrs. The program graphically depicted the displacement, velocity and the root mean square of both. Below are the results for the minimum and maximum displacement at each bridge.

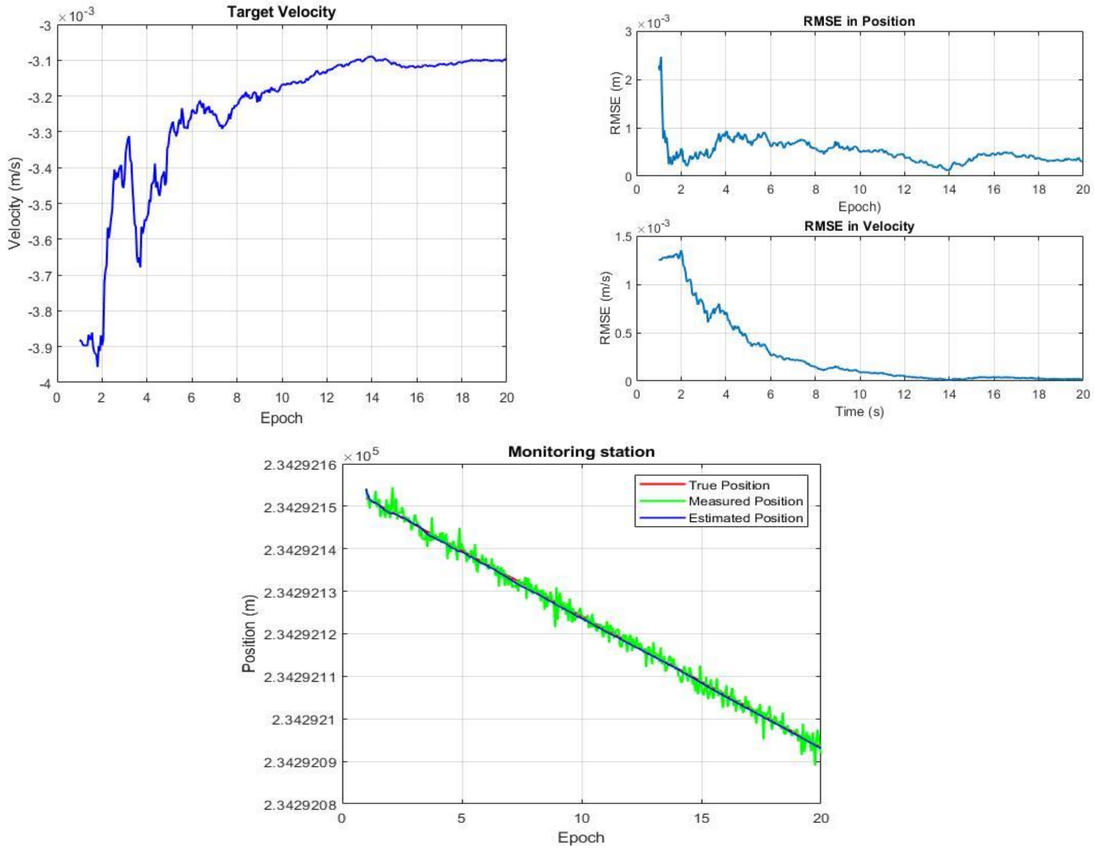


Figure 2: Velocity and mean root square model and Kinematic model of easting axis of MN 12 (chanchaga)

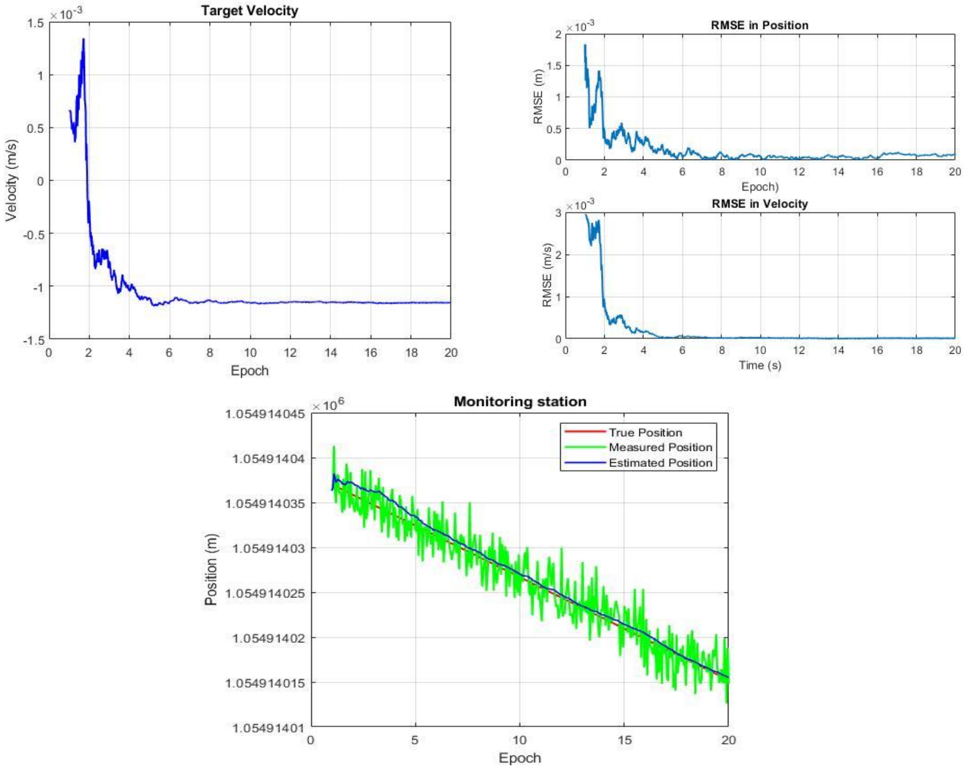


Figure 3: Velocity and mean root square model and Kinematic model of Northing axis of MN 12 (Chanchaga)

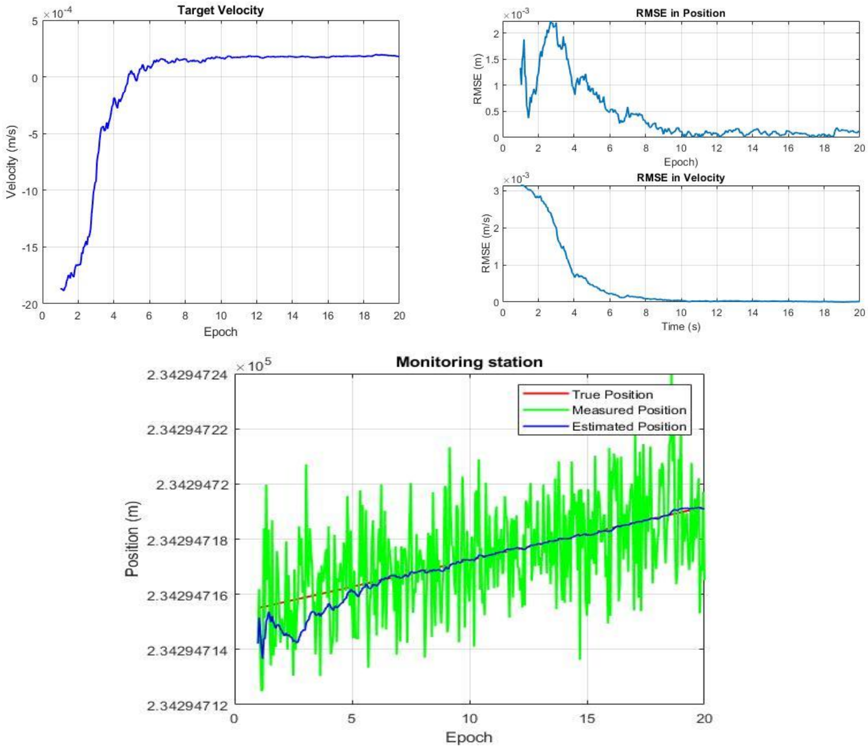


Figure 4: Velocity and mean root square model and kinematic model of Easting axis of MN 22 (Chanchaga)

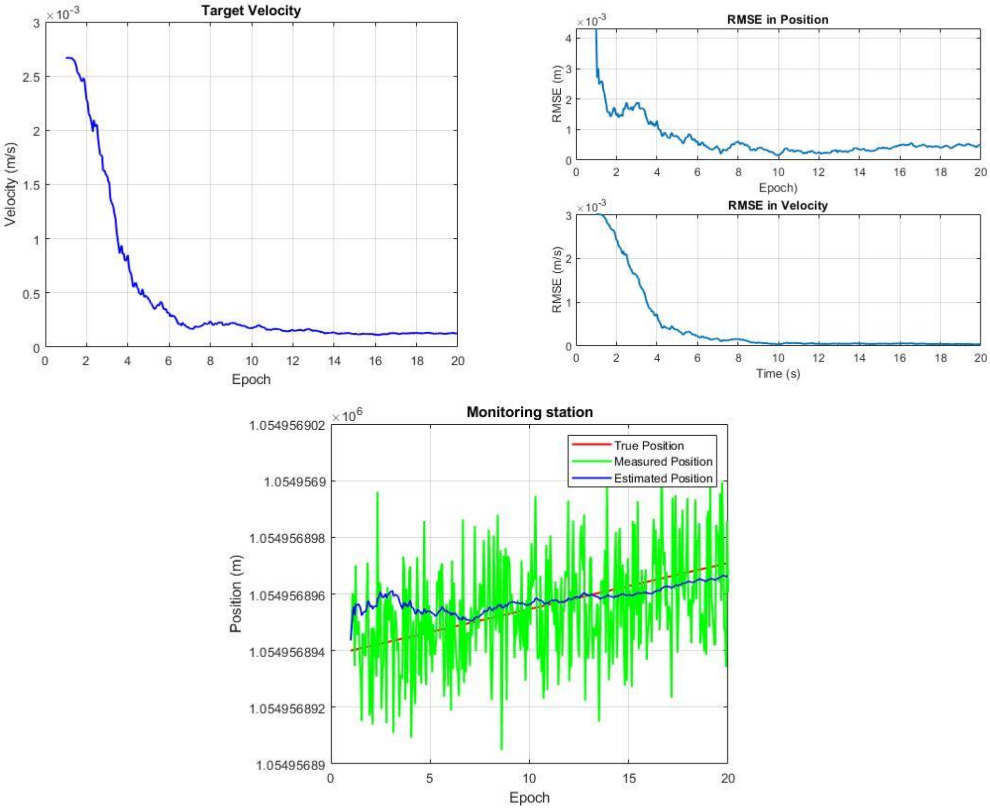


Figure 5: Velocity and mean root square model and Kinematic model of Northing axis of MN 22 (Chanchaga)

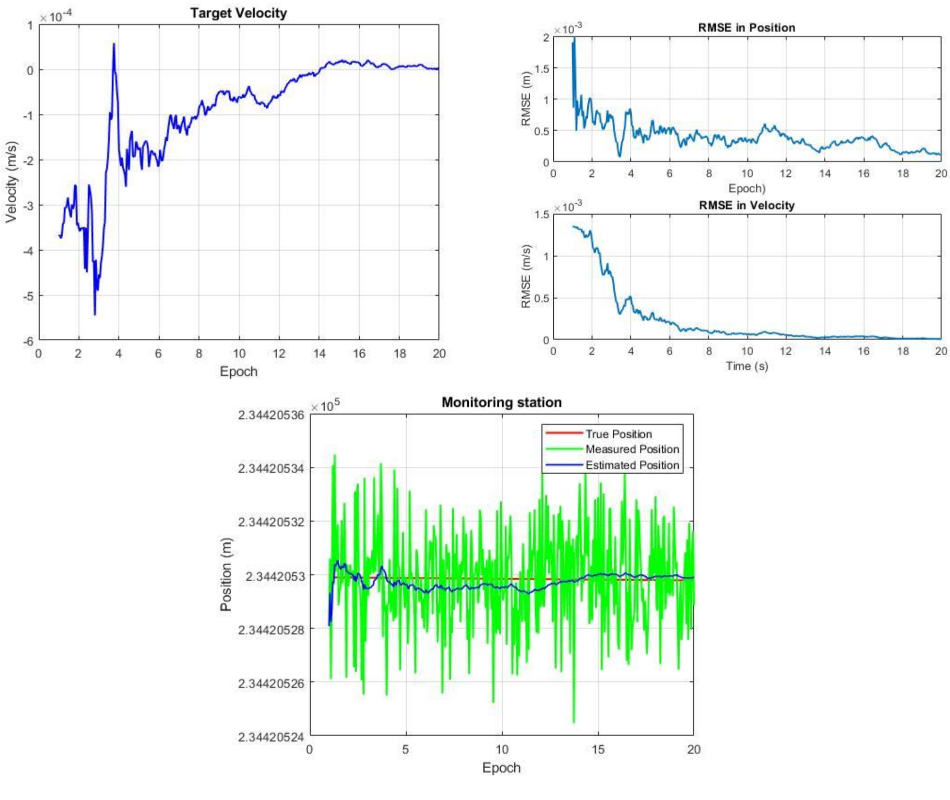


Figure 6: Velocity and mean root square model and kinematic model of Easting axis of MN 45 (Tungan Goro)

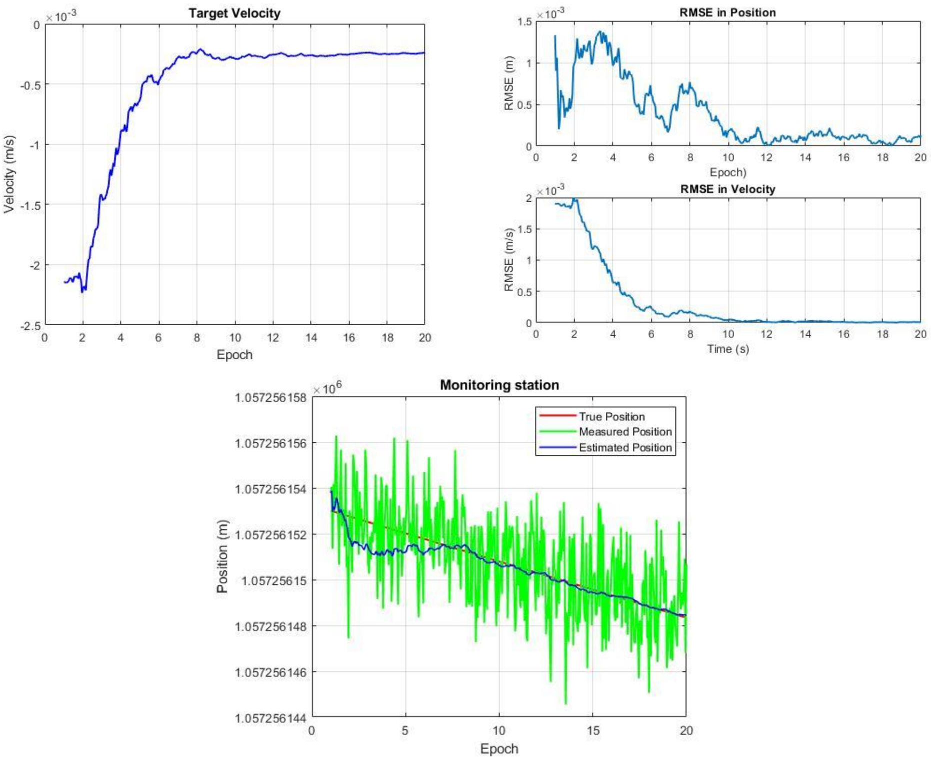


Figure 7: Velocity and mean root square model and kinematic model of Northing axis of MN 45 (Tungan Goro)

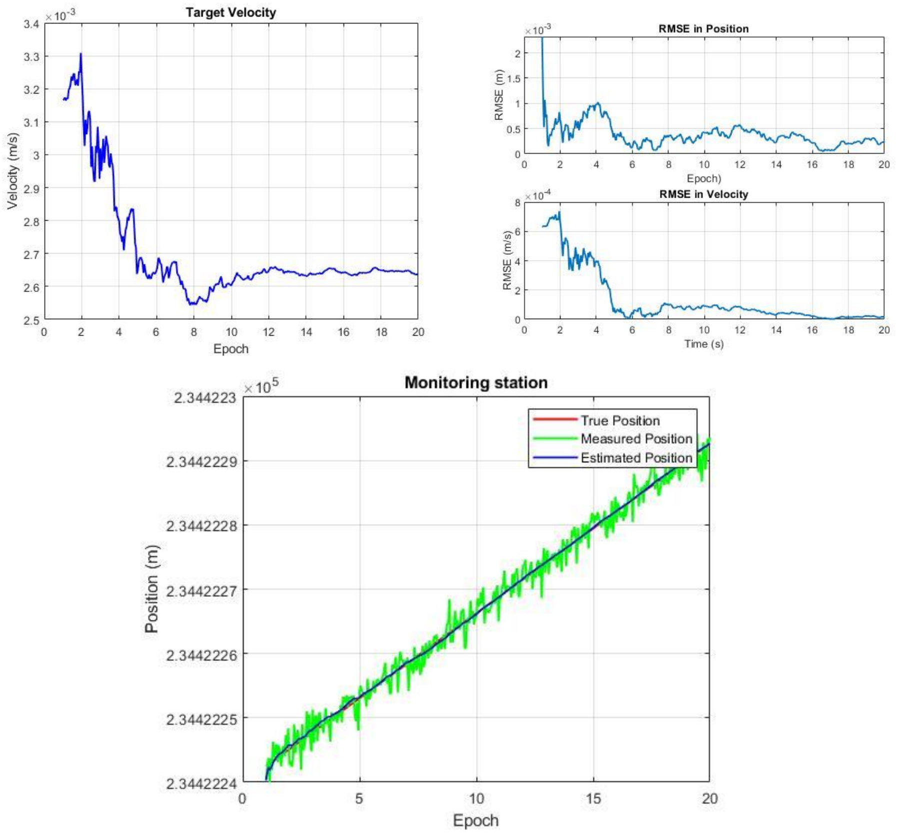


Figure 7: Velocity and mean root square model and kinematic model of Easting axis of MN 50 (Tungan Goro)

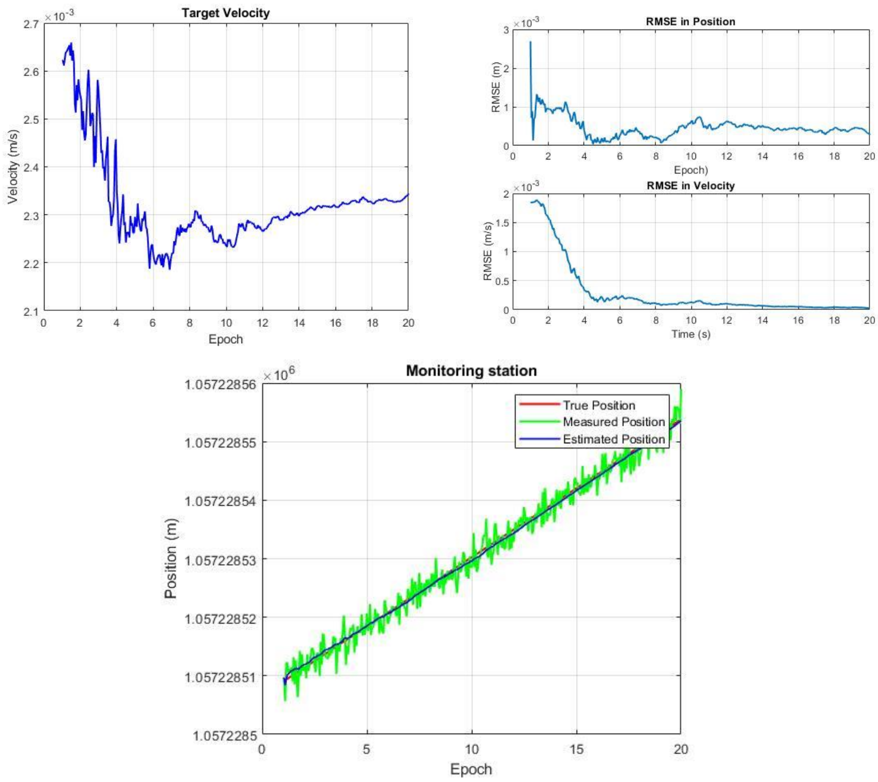


Figure 8: Velocity and mean root square model and kinematic model of Northing axis of MN 50 (Tungan Goro)

From the kinematic models above, the following table was computed and displayed.

Table 4.8A: Displacement of Chanchaga Bridge in 5years.

Station no.	Change in 5years (X)	Change in 5years (Y)	Change in 5years (Z)
MN 12	0.6CM	2.5CM	0.2CM
MN 22	0.7CM	0.4CM	0.55CM

Table 4.8B: Displacement of Tungan Goro Bridge in 5years.

Station no.	Change in 5years (X)	Change in 5years (Y)	Change in 5years (Z)
MN 45	1.2CM	0.57CM	1.5CM
MN 50	6CM	5CM	0.2CM

Conclusion

This study drew the attention of the appropriate authorities to the dangers posed by structural deformation to the safety of motorist that ply the two bridges covered in this research. It was observed that Chanchaga Bridge is more stable than Tungan Goro

Recommendations

The following recommendations are advanced from the above discourse:

i. RTK data and wavelet transform should be adopted for structural health monitoring due to it speed of execution, low cost and reliability at all temperature and seasons. The outliers due to multipath error from moving vehicles can be effectively minimized using wavelet transform.

ii. It is also recommended that such studies be conducted annually and extended to all bridges in Nigeria.

iii. There is need for capacity building and training of surveyors on the use of GNSS RTK for structural health monitoring.

REFERENCES

Roberts, G. W., Tang, X., & Brown, C. J. (2019). Measurement and correlation of displacements on the Severn Suspension Bridge using GPS. *Applied Geomatics*, *11*(2), 161-176.

Shen, N., Chen, L., Liu, J., Wang, L., Tao, T., Wu, D., & Chen, R. (2019). A review of global navigation satellite system (GNSS)-based dynamic monitoring technologies for structural health monitoring. *Remote Sensing*, *11*(9), 1001.

Stewart, M. G., Wang, X., & Nguyen, M. N. (2019). Climate change adaptation for corrosion control of concrete infrastructure. *Structural Safety*, *35*, 29-39.

Stipanovic, I., Connolly, L., Skaric Palic, S., Duranovic, M., Donnelly, R., Bernardini, I., & Bakker, J. (2020). Reliability based life cycle management of bridge subjected to fatigue damage. *Frontiers in Built Environment*, *6*, 100.

Thill, M., Konen, W., & Bäck, T. (2017). Time series anomaly detection with discrete wavelet transforms and maximum likelihood estimation. In *Intern. Conference on Time Series (ITISE)* (Vol. 2, pp. 11-23).

Viset, F., Helmons, R., & Kok, M. (2022). An Extended Kalman Filter for Magnetic Field SLAM Using Gaussian Process Regression. *Sensors*, *22*(8), 2833.

Wymeersch, H., Shrestha, D., De Lima, C. M., Yajnanarayana, V., Richerzhagen, B., Keskin, M. F. & Parkvall, S. (2021, September). Integration of communication and sensing in 6G: A joint industrial and academic perspective. In *2021 IEEE 32nd Annual International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC)* (pp. 1-7). IEEE.

Yunus, M. Z. M., Ibrahim, N., & Ahmad, F. S. (2018, February). A review on bridge dynamic displacement monitoring using global positioning system and accelerometer. In *AIP Conference Proceedings* (Vol. 1930, No. 1, p. 020039). AIP Publishing LLC.

Zimmermann, F., Schmitz, B., Klingbeil, L., & Kuhlmann, H. (2018). GPS multipath analysis using fresnel zones. *Sensors*, *19*(1), 25.

Živanović, S., Pavic, A. L. E. K. S. A. N. D. A. R., & Reynolds, P. (2018). Vibration serviceability of footbridges under human-induced excitation: a literature review. *Journal of sound and vibration*, *279*(1-2), 1-74.

Image Fusion for Improving Spatial Resolution of Multispectral Satellite Images

Gobir M. O. [1a] **& Etim, E. E.** [1b]
Department of Surveying and Geo-Informatics, Federal University of Technology Minna
[a]imamrahmah9@gmail.com; [b]geoetim@gmail.com
Corresponding Author: imamrahmah9@gmail.com

Abstract

With respect to remote sensing application, the growing availability of space borne or satellite sensors gives an opportunity to create a better dimension for increased resolution for images. Increased spatial resolution is often characterized by limited coverage area that is a large coverage area often has a reduced spatial resolution while small coverage is characterized with high spatial and temporal resolution. Also, images with high spatial resolution are known to have low spectral bands (resolution). This has been a major challenge in the accessibility of satellite images for different application since resolution is an integral aspect of accuracy in analysis. The concept of image fusion is described as the process of combining relevant information from two or more images into a single image. It is employed to increase spatial and spectral resolution of remotely sensed data by combining a high spatial but low spectral resolution image with a low spatial high spectral resolution image. In this research, remote sensing image fusion techniques was investigated with the aim to look at approaches that can produce very usable images from diverse sensor features to balance each other. Fusion techniques such as Brovey, Gram Schmidt, Intensity-Hue-Saturation, Wavelet Transform and Principal component analysis were applied on Landsat image (30 meters) which was fused with a high-resolution image of 0.5 meters. Statistical and textural analysis were used as standards to measure spectral and spatial evaluations for the output fused images which included root mean square, correlation coefficient, signal to noise error, average gradient, entropy, and mean. The findings indicated the effectiveness of these techniques, mostly the Intensity-Hue-Saturation, Brovey and the Grams Schmidt processes as they produced a higher quality and improved image. In both statistical and textural measure, the Gram Schmidt and IHS process were more efficient and were deemed better. Also, in terms of statistics, IHS and gram Schmidt process has less error in terms of RMSE and ERGAS as well as Average Gradient. The statistics showed that the detail of the original image improved better even with the spectral distortion.

Keywords: Image Fusion, Spatial Resolution, Statistical Analysis, Textural Analysis, Fusion techniques.

Point and Spatial Evaluation of Some Selected Commercial Software Used in UAV Image Processing

Aliyu, K.A.[1a], Nwadialor, I.J.[1b] & Odumosu, J.O.[2]

[1]*Department of Surveying and Geoinformatics, Federal University of Technology, Minna, Niger State, Nigeria*

[2] *Department of Surveying and Geoinformatics, Federal University of Oye-Ekiti, Ekiti State, Nigeria.*

[a]Kpotunaliyu92@gmail.com; [b]drijinwadialor@yahoo.com;

Corresponding author: Kpotunaliyu92@gmail.com

Abstract:

The developments in the field of photogrammetry, aided by the popularization of UAVs, have sparked the creation of various software packages that offer photogrammetric and/or Structure-from-Motion (SfM) processing. Despite the presence of many open-source solutions, commercial solutions remain very popular among users, especially outside the photogrammetric community. This is mainly due to the fact that commercial solutions tend to provide fairly accurate results with simpler and more streamlined user interfaces. A simplified workflow offers utility to a broad user base, but can hide the more complex functionality, which can be valuable to expert users (Surveyors and Engineers). This is particularly important in projects that require detailed metrics such as high precision mapping, where the user often requires more control of the processing parameters.

The aim of this project is to make evaluation of two image processing software (Agisoft and Pix4D) in terms precised position and spatial feature representation in both vector and raster data format using a conventional survey technic as a validation tool for the assessment. The equipment used to ensure a high level of quality model is the the Hi-target DGPS v30 and the DJI Mavic Air 4 PRO drone. Hi-target DGPS v30 module were used to track the exact position of tie points on the ground. Meanwhile the DJI Mavic Air 4 PRO drone is used as data inputs (images) for the software packages stated. In addition, the drone is used to fly over the area of interest (Federal University of technology main Campus) with a challenge of homogenous surface for 3D surface modeling. Based on the output, it shows that each software packages produce slightly different outputs. This paper summarizes the outputs and discusses the key elements in each software packages. This variation might be useful for future references in 3D surface modeling that can conform in different applications requirements. As far as geomatics requirements are concerned, it is still in the interest of the user to understand their results at a detailed enough level to be able to assess the quality of the results and determine if any part of the project may be improved.

Keyword: *Photogrammetry; Bundle Adjustment; Commercial Software; Conventional Survey.*

1.0 INTRODUCTION

The photo processing with aero triangulation workflow is also named as bundle adjustment technique because it is based on the idea that many light rays which come from the light source (camera sensor) are forming a bundle of rays all intersects to generate spatial positions (Ahmed 2017). The bundles from all involved images are later adjusted simultaneously so that corresponding light rays intersect at positions of ground features [Wolf 2000]. Collinearity equations are the formula used as a mathematical model to adjust these bundles using least squares. However, these equations are not linear and thus, need to be linearized for an optimal solution. This can be obtained mathematically by adopting the first order terms of Taylor's theorem using initial values to the unknowns (Suvig, 2008).

UAV Had its beginnings with military applications, its use in the geomatics domain has continued to increase. Furthermore, the integration of imaging sensors, and recently positioning apparatuses, such as GNSS receivers, has increased its potential for close-range applications, as it complements classical terrestrial close-range data acquisition (Nex and Remondino 2014).

In this paper, a critical analysis of the bundle adjustment results of two-commercial software (Photo Scan and Pix4D) was performed. This involved the processing of image data in Agisoft Photo Scan and Pix4D in order to derive detailed metrics. These metrics were then Validated by Conventional survey technic to verify the results given by the two-processing software (Photo Scan and Pix4D Mapper). The point and spatial feature in the othomosaic representation, DSM and DEM were also generated from both software in other to make comparison and validated with Topographic DTM obtain from the conventional survey technics and USGS downloaded DEM.

2.0 REVIEW OF LITERATURE

As the name suggests, an Unmanned Aerial Vehicle (UAV) comprises a flying platform that is controlled from a ground station using a communication data link (Colomina.I, 2014). Although it had its beginnings with military applications. its use in the geomatics domain has continued to increase. its use in the geomatics domain has continued to increase. Nevertheless, their spread has run up against the distrust of scientific community. Indeed, they have become increasingly popular and widespread in the last two decades thanks to the fast improvement and integration of platforms, of integrated circuits and radio-controlled systems and software applied for reconstructing the surveys (Nex, 2014). Furthermore, the integration of imaging sensors, and recently positioning apparatuses, such as GNSS receivers, has increased its potential for close-range applications, as it complements classical terrestrial close-range data acquisition (Nex and Remondino, 2014).

First investigations dated back to the Carnegie Mellon University, which applied drones in the robotics context. Works related to the study of the potential of the spatial details in the 3D point cloud for urban and natural terrain surveys can be found in 2003 (Thrun, 2003). Even if the complete workflow for the digital surface model generation was introduced by (Nagai *et al.*,2008). Recent technical electronic and optical development for aerial platforms and the devices mounted on them have improved the accuracy of UAV trajectory for 3D modelling.

2.1 Types of UAV

UAV are generally classified into two main categories;

1. Fixed-wing UAV*:* Unmanned airplanes (with wings) that require a runway to take-off and land. Fixed-wing UAV generally have long endurance and can fly at high cruising speeds. Different wing designs affect lateral stability, especially in the cases of UAS and MAV (Micro or Miniature) that use high aspect ratio wings and are therefore sensitive to lightly turbulent air. This can pose a challenge when such classes of UAS are employed for ISR tasks.
2. Rotary-wing UAV: Also called rotorcraft UAVs or vertical take-off and landing (VTOL) UAVs. Their primary advantages are hovering capability and high maneuverability which make them useful for many robotic missions. In military applications, the objective is that small VTOLs would be positioned in a place where they can observe the scene where there is enemy activity of interest. The small VTOL can then observe movement (change detection) and notify the human user by sending a picture of the object that has moved (changed). This reduces the fuel required to operate, increases the time on station significantly and eliminates the users need to "watch" the video screen. This feature can also be extremely useful in civilian applications for example in monitoring of wildlife, infrastructure, border control and others. A rotorcraft UAV may have different configurations, with main and tail rotors (conventional helicopter), coaxial rotors, tandem rotors; multi-rotors, etc. Other types include;
   i. Blimps: For example, balloons and airships that are lighter than air and have long endurance, fly at low speeds, and generally are large sized.
   ii. Flapping-wing UAV: Have flexible and/or morphing small wings inspired by birds and flying insects. There are also some other hybrid configurations or convertible configurations, which can take-off vertically and tilt their rotors or body and fly like airplanes (for example the Bell Eagle Eye UAV).

Bendea *et al*, (2007) have shown that rotary wing systems can be adopted to operate closer to objects than fixed wing UAVs, due to larger flexibility in their control, even if they can stay for less time in the air, covering smaller areas. Balloons and gliders are controlled by ropes, which limit the flight altitude and distance from the operator. In addition, they are strongly influenced by wind, more than rotary and fixed wing UAVs. Like these systems, also the airship application is limited by the climatic conditions, but this platform can stay longer in the air than the fixed and rotary wing platforms.

Alternatively, they could be classified according to the size, the weight, the endurance, the range and the flight quote in;

Tactical UAVs: this category includes micro and mini-UAV (their mass range is by 1000 kg), with a close-, short-, medium-range in distance (the range is comprised between few km and 500 km) and a flight altitude between few hundred meters to 5km and the endurance from some minutes to 2-3 days

Table 1: Classification of tactical UAVs

Name of category	Acronym	Weight [kg]	Range [km]	Flight Altitude [m]	Endurance [hours]
Micro	Micro	<5	<10	250	1
Mini	Mini	25-150	<10	150-300	<2
Close Range	CR	25-150	10-30	3000	2-4
Short-Range	SR	50-250	30-70	3000	3-6
Medium Range	MR	to 1250	70-200	5000	6-10
Medium Range Endurance	MRE	to 1250	>500	8000	10-18
Low Altitude Deep Penetration	LADP	to 350	>250	50-9000	0,5-1
Low Altitude Long Endurance	LALE	<30	>500	3000	>24
Medium Altitude Long Endurance	MALE	to 1500	>500	14 000	24-48

UAVs for geomatics applications are mainly tactical drones (Table 1) and they can be further classified according to their engine/propulsion system in:

- unpowered platforms, e.g., balloon, kite, glider, paraglide;
- powered platforms, e.g., airship, glider, propeller, electric, combustion engine.

Alternatively, they could be classified according to the aerodynamic and "physical"

features as:

- lighter-than-air e.g., balloon, airship;
- rotary wing, either electric or with combustion engine, e.g., single-rotor, coaxial, Quadro-copter, multi-rotor;
- fixed wing, either unpowered, electric or with internal combustion engine (ICE), e.g., glider or high wing. [3]

Based on the construction of UAVs, there are two types that are mostly used for applications in geomatics, and there are fixed and rotary wing drones (Figure 2).

a) Fixed wing (Gate wing*)*

b) Rotary wing (md4-1000)

Figure 1: Micro drones for applications in geomatics, two most used construction

3.0 MATERIALS AND METHODS

Before the image acquisition was performed, a topographical survey was conducted around the area of interest using a Hi-Target DGPS v 30. This is basically carried out in other to obtains the DTM of the area that could be used to make a comparism analysis of the 3D reconstruction model from process image data of the project site. Traverse points were measured around the Project Site, from which detail points on the area were measured. Some of the detail points were used as Ground Control Points (GCP). The whole traverse network was attached to the UTM Minna datum system using a GNSS receiver and the RTK (Rapid Time Kinematic) method.

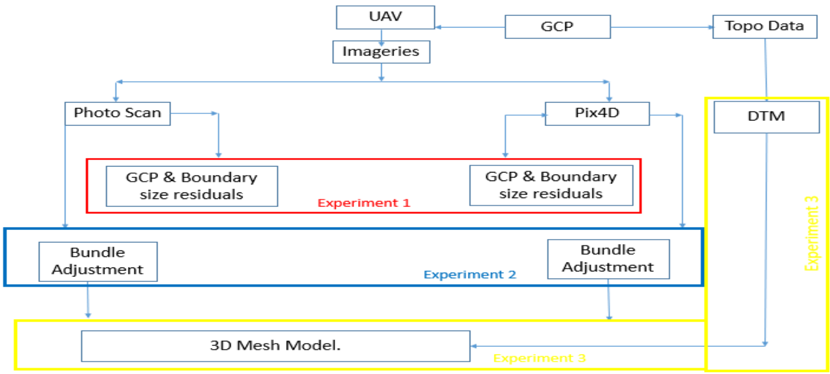


Figure 2: Flow Chart for Data Collection Process

A rough flight plan was designed beforehand to ensure enough overlap and side-lap between the images and strips, respectively, and given to the pilot. The final flight configuration resembled the designed one, although some modifications needed to be performed in the field.

3.1.1 Reconnaissance

To accomplish the aim of this research, the first thing was to get acquainted to the study area, identify the extent of the area and select a site plan to ensure a smooth and successful mission. The weather condition, physical condition, and a suitable terrain were put into consideration.

3.1.2 Establishing GCPs

Pre-marking and establishment of ground control points is major aspect in achieving an accurate 3D information as their measurement is an important aspect of georeferencing (Gindraux *et al*, 2017). Where and how to establish GCPs over the area of concentration is a very important aspect to be considered. To get a reasonable result, it is best to use a minimum of 5 GCPs depending on the extent of area to be considered, as GCPs densification and distribution has a direct influence on the accuracy of results that will be acquired (Tahar *et al.*, 2012). In this study, about 20 GCPs were established and evenly distributed across the study area. Plate 3.1 presents the style adopted in pre-marking the GCPs established over the study area.

Figure 3: An established Ground Control Point

It is of great significance to make use of high accuracy differential global positioning system (DGPS) receivers for the acquisition of ground control points in any UAV mission. The coordinate of the GCPs established are shown in Table 2

Table 2: Coordinates of established GCPs

S/NO	DISCRIPTION	NORTHING	EASTING	HEIGHT
1	GPS02	1054839.606	220651.0028	236.3418
2	GPS 03	1054895.011	220479.4413	233.8623
3	GPS 04	1054608	220307.59	238.2929
4	GPS 08	1055171.226	220152.68	228.2967
5	GPS 09	1055127.084	220423.7878	232.521
6	GPS 10	1055018.8	220211.809	232.2377
7	GPS 11	1054858.332	220337.637	234.3433
8	GPS 12	1054789.379	220267.28	234.11

3.1.3 Flight Plan Design

The flight plan was designed to ensure a safe and smooth flight mission. The plan of this study area revealed that 7 batteries will be needed for the completion of this mission and also, it will take the unmanned aerial vehicle (DJI mavic air pro), about 98minutes to complete flight operation of 21 hectares at 30 meters flying height. The end lap and side lap percentage selected for this work was 75% and 65% overlap respectively. Mission Planning utilizes principles of Photogrammetry such as making sure that a group of photographs are oriented with respect to one another in a continuous strip or block configuration, the angle of Incidence, Ground Resolution, and more. Plate 3.2 is the flight plan of the study area.

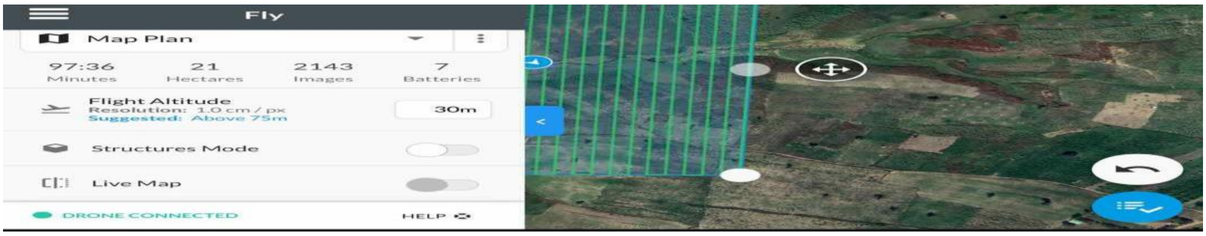


Figure 4: Flight plan design

3.2 UAV DATA ACQUISITION

Unmanned aerial vehicle are guided autonomously by a remote control, it carries sensors, target designators, offensive ordnance or electronic transmitters designed to avoid enemy targets. The type of UAV used in this work is the DJI Mavic Air Professional (Rotor-wing quadcopter UAV). The reason why this particular type of UAV was chosen for this work is due to its low cost and affordability. The imaging sensor attached to the UAV is an RGB camera aimed at obtaining high resolution photographs for accurate result, examples of the other sensors attached to a UAV include; magnetic field change sensor, speed-distance sensor, accelerometer. Plates 3.3 and 3.4 are the photographs of DJI Mavic Air Professional and its Remote Controller.

Figure 5: DJI Mavic Air Pro

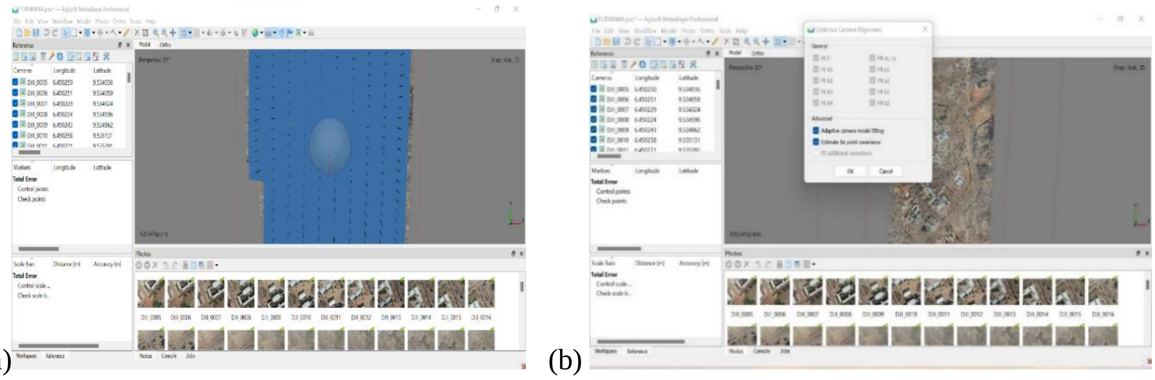
Table 3: Summary of photogrammetric parameter

Parameter	Value	Parameter	Value
Flying height	240m	Pixel size	0.00068cm
Flight lines	1	Camera	FC6310, 8.8, 4864x3648
Photos	993	Time of survey	3h
Ground Control Points	8	Weather	Sunny with no clouds
Project area size	1.642kmsqr.	Wind	Weak

3.3 UAV IMAGE PROCESSING

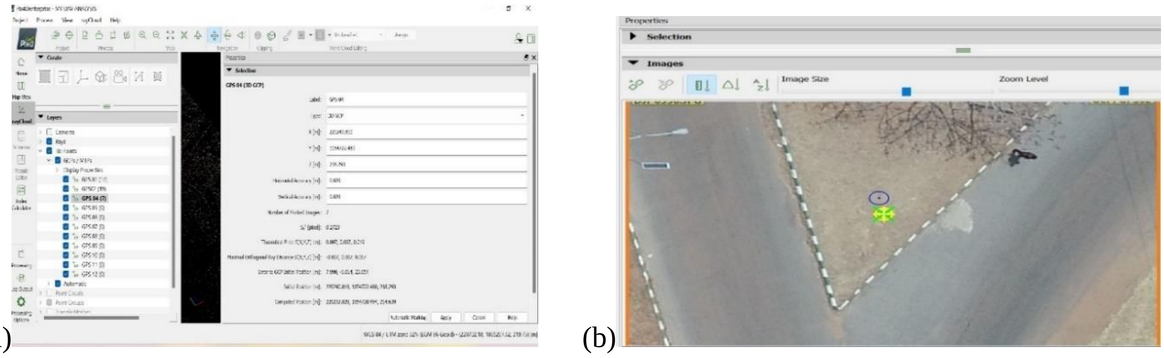
3.3.1 Initial processing

For initial processing, the first executed procedure was to compute key points, using scale- invariant feature transform (SIFT) for the automatic extraction of the conjugate points, and for computing the matches (Lowe, 2004). This was followed by calibration of the image for the accurate generation of orthophoto.



(a) (b)

Figure 6: Agisoft interface for cameral location



(a) (b)

Figure 7: Pix4d interface for Gpc Ground Marking

4.0. RESULTS

4.1 EXPERIMENT 1:

In the first experiment, the main objective of Experiment 1 was to investigate whether the quality of this result in terms of positioning and spatial features can be improved. The evaluation was based on the GCP residual RMS. The GCP residuals are shown in Tables (a) and (b), respectively

Table 4:*Results of the external orientation process showing the positions and attitudes of each camera station, together with the sparse point clouds generated from the respective feature matching process. Both software Generated its own tie point measurements. (**a**) Photo Scan (**b**) PIX4D.*

Label	X error (m)	Y error (m)	Z error (m)	Total (m)	Image (pix)
GPS02	-1.09375	0.145205	0.112022	1.10902	129.534 (3)
GPS 03	-0.806859	1.48691	0.0410005	1.69222	248.918 (2)
GPS 04	-0.0277007	1.88657	0.526799	1.95894	266.377 (2)
GPS 08	0.373482	0.523766	0.0362282	0.644308	110.721 (2)
GPS 09	-0.0331199	-0.537663	-0.140324	0.556659	49.536 (4)
GPS 10	1.08107	2.32016	0.393249	2.58969	146.333 (6)
GPS 11	1.56044	-7.50888	-0.29559	7.675	315.316 (8)
GPS 12	-0.940182	-0.612746	0.114699	1.12808	169.923 (2)
Total	**0.899742**	**2.9261**	**0.26644**	**3.07288**	**214.325**

Table 5. Control points.
X - Easting, Y - Northing, Z - Altitude.

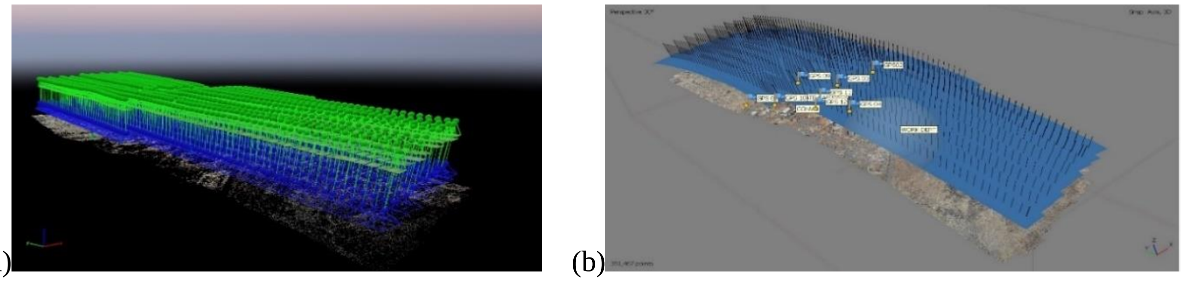
GCP Name	Accuracy XY/Z [m]	Error X [m]	Error Y [m]	Error Z [m]	Projection Error [pixel]	Verified/Marked
GPS 01 (3D)	0.020/ 0.020	0.000	-0.319	0.598	0.311	14 / 17
GPS02 (3D)	0.020/ 0.020	0.022	0.021	0.040	0.372	19 / 19
GPS 04 (3D)	0.020/ 0.020	-0.007	0.008	-0.024	0.180	7 / 7
GPS 08 (3D)	0.020/ 0.020	-0.017	-0.004	0.008	0.342	8 / 8
GPS 09 (3D)	0.020/ 0.020	0.008	-0.011	0.073	0.273	10 / 11
GPS 10 (3D)	0.020/ 0.020	0.006	0.027	-0.079	0.105	6 / 6
Mean [m]		0.001921	-0.046555	0.102732		
Sigma [m]		0.012214	0.122755	0.226773		

In the case of the spatial features, below are the validation processes

Figure 8: Pix4d interface for Gpc Ground Marking.

4.2.1 BOUNDLE ADJUSTMENT.

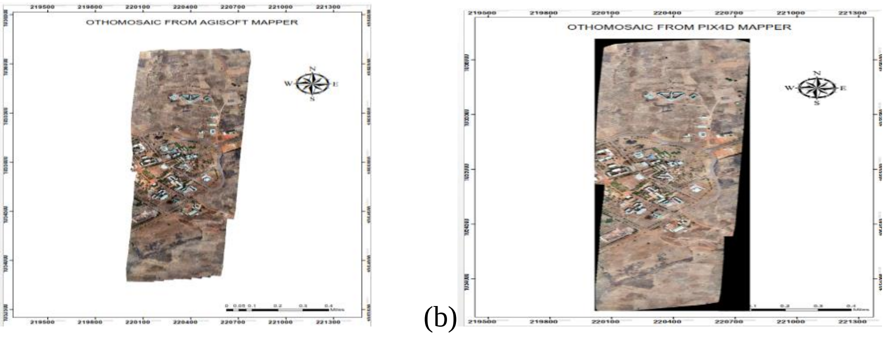
All Two software succeeded in computing the orientation parameters of all images in the project. Results from Photo Scan and Pix4D where well examined as sown bellow.



(a) (b)

Figure 9: *Results of the external orientation process showing the positions and attitudes of each camera station, together with the sparse point clouds generated from the respective feature matching process. Both software Generated its own tie point measurements. (**a**) Photo Scan (**b**) PIX4D.*

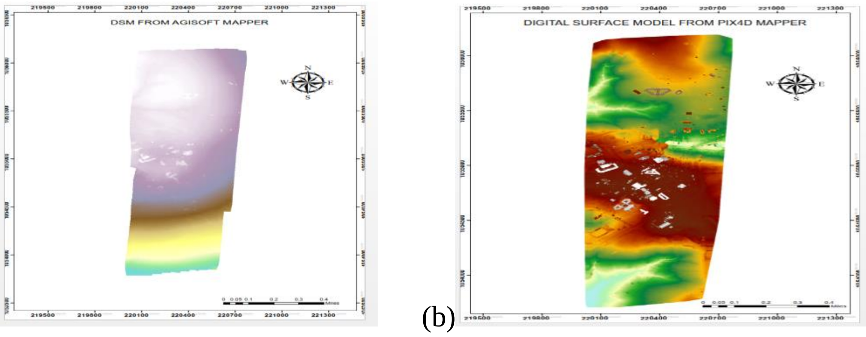
4.3. **OTHOMOSAIC, DSM DEM IMAGES**



(a) (b)

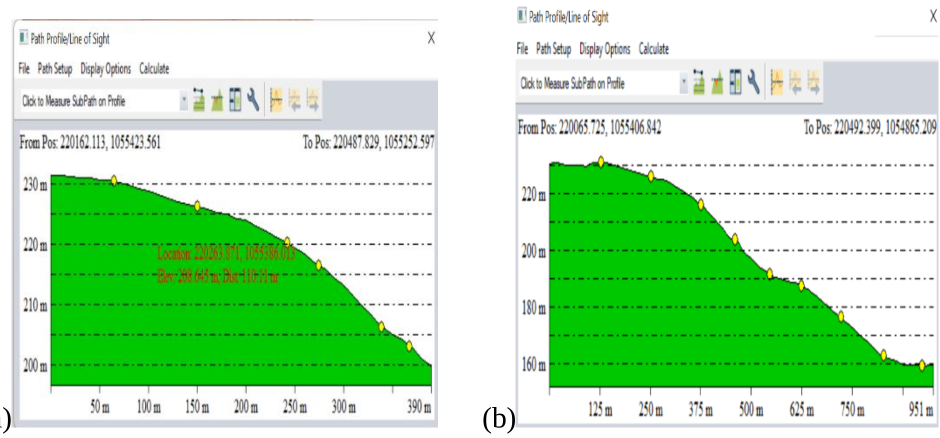
Figure 10: Map of the Dsm (a) Photo Scan (b) PIX4D.

4.4 DIGITAL SURFACE MODELs (DSM)



(a) (b)

Figure 11 *Map of the Dsm (**a**) Photo Scan (**b**) PIX4D.*



(a) (b)

Figure 12: Profile of the Dem (a) Agisoft (b) PIX4D.

4.5 DISCUSSION

Experiment 1 showed that using the same GCP and under similar weighting conditions, Photo Scan's and Pix4D mapper both produce most likely a similar result and have been fully justify by ground and satellite data.

5.1 CONCLUSION

This research shows the output from two software packages from the aspects of special feature data representation and validation. There is no the best software package that can solve the visualization in all criteria mentioned. This research highlights which software package that best in each category. This can be seen from Pix4D that it best at modelling the local elevations like trees, benches, buildings etc. which is very important. Agisoft PhotoScan gives the by far highest resolution on their mesh.

5.2 RECOMENTATION

1. Both software is highly is recommended as a better solution for a photogrammetry background user.
2. Prior knowledge in photogrammetry is required due to its method which requires camera calibration, sensor size parameter inputs and other related information.
3. The conventional survey data and online satellite and imagery, DSM, DTM can be used to validate the Conclusions from Experiments 1 and 3 for both Photo Scans and pix4D mapper results.

REFERENCES

applications for UAV/drones: a survey, Progress in Systems Engineering. Springer, pp. 449-454.

Clarke, R., 2014. The regulation of civilian drones' impacts on behavioural privacy. Computer Law & Security Review 30, 286-305.

Clarke, R., Moses, L.B., 2014. The regulation of civilian drones' impacts on public safety. Computer Law & Security Review 30,263-285.

Eisenbeiss, H., 2009. UAV photogrammetry. ETH Zurich. Izham, M.Y., Uznir, U., Alias, A.R., Ayob,

K., Wan Ruslan, I., 2011. Influence of georeference for saturated excess overland flow modelling using 3D volumetric soft geo-objects. Computers & Geosciences 37, 598-609.

Masehian, E., Mohamadnejad, N., 2015. Path planning of nonholonomic flying robots using a new

virtual obstacle method, Robotics and Mechatronics (ICROM), 2015 3rd RSI International Conference on. IEEE, pp. 612-617.

Nex, F., Remondino, F., 2014. UAV for 3D: a review. Applied geomatics 6, 1-15.

Suhaibah, A., Uznir, U., Rahman, A.A., Anton, F., Mioc, D., 2016. 3D Geomarketing Segmentation: A Higher Spatial Dimension Planning Perspective. Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci. XLII-4/W1, 1-7.

Syahiirah, S., Uznir, U., 2018. Topological information extraction from buildings in CityGML. IOP Conference Series: Earth and Environmental Science 169, 012088.

Eisenbeiss H., UAV photogrammetry. Dissertation ETH No. 18515, Institute of geodes and Photogrammetry, ETH Zurich, Switzerland, 2009.

Nex Francesco, Remondino Fabio, UAV for 3D mapping applications: a review, Applied Geomatics Italy. 03/2014. DOI:10.1007/s12518-013-0120-x

Everaerts J., The use of Unamnned Aerieal Vehicles (UAVs) for Remote Sensing and mapping, International Archives of the Photogrammetry, Remote Sensing and spatial Information Sciences, Vol. XXXVII. Part B1. Beijing, China, 2008. Pp. 1187-191

Nebiker S., Annen A., Scherrer, D. Oesch D., A light-weight multispectral sensor for micro-UAV-opportunities for very high resolution airborne remote sensing, International Archives of the Photogrammetry, Remote Sensing and spatial Information Sciences, Vol. XXXVII, Part B1, Beijing, China 2008. pp. 1201-1206.

SUB-THEME 3:
ARCHITECTURE, RESILIENCE AND HEALTHY BUILDINGS IN PANDEMIC ERA

Nigerian Prisons Reformation! Panacea for Reduction of Recidivism - Case Study of Minna Medium Security Prison

Abdul, C. I.[a], Ekule, A. A.[b], Idachaba, M. K.[c], Nuhu, A. A.[d]
[a]ileanwa@graduate.utm.my; [b]ekuleadejoh@yahoo.com; [c]kidachaba@yahoo.co.uk; [d]arcnuhu@gmail.com
Department of Architectural Technology, Kogi State Polytechnic, Lokoja, Nigeria.
Correspondence email: ileanwa@graduate.utm.my

Abstract

Security outfits that are basically meant to separate those that causes harm to the society with the aim of a better and acceptable societal characteristics after a period of time of separation are referred to as prisons. The aim of this review is to investigate the impact of reformation on reduction of recidivism among Nigeria Prison Inmates using Minna Medium Security Prison in Niger State, Nigeria as case study. The study found out that recidivism is prevalent among jail offenders in Nigeria as a result of inadequate reformative facilities and in some cases the lack of it. The study aligns its findings on existing knowledge that reformation of prisons should not be by nomenclature change alone but functional facilities like educational programmes, skills acquisition programmes, counselling services, religious services, agricultural services and recreational services should be available for those in prisons to assist in their reformation rather than deformation.

Keywords: Recidivism, Facilities, Inmates, Prison, Reformation.

Introduction

A place where people who are found guilty after a trial are physically emasculated for rehabilitation with the goal of turning them into law-abiding, respectable citizens once they are released is referred to as prison. Regarding offenders, incarceration serves four key purposes: to isolate offenders to stop them from committing other crimes, to punish offenders for their crimes, to discourage others from committing crimes, and to rehabilitate convicts (Emasealu, 2019). Prison is also seen as an organized, transitional, and entire confinement. Additionally, it serves as a detention facility for criminal suspects pending trial until the outcome of their case (Adegboyega, 2020). A prison is a physical building in a specific area where a number of people are housed in highly specialized conditions, make use of the resources available to them, and adapt to the options that are presented by a special kind of social environment that is so very different from the rest of society (Akpojaro and Omogbhemhe, 2017). Prison is a facility where those who had broken the law were held. It is a facility that turns criminals into law-abiding citizens and lowers recidivism (Rao *et al.*, 2019). Retribution (punishment), deterrence, incapacitation (preventing the prisoner from reoffending while they are in prison), and rehabilitation (reducing the risk that they will re-offend after release), have historically been the four possible purposes of imprisonment (Beyrer *et al.*, 2016). Various names like penitentiaries, reformatories, jails and correctional facilities have been used by different countries to describe prisons. The common feature of a prison no matter the name is the confinement of an individual to a certain space and form of lifestyle for a period of time. Some criminals repeat their crimes on a regular basis. The continuation of criminal conduct after a criminal has served a prison sentence for a past offence is known as recidivism. Recidivists, or individuals who relapse into crime and criminality, are becoming far more prevalent in Nigeria's jail system (Adegboyega, 2020). In general, prisons on the African continent—and Nigeria in particular—are thought to be overcrowded, in poor physical condition, and lacking in maintenance. The perceptions also include that aggression by inmates and warders is commonplace given the difficulties associated with illnesses and ailments among people who are confined (Nwaopara and Stanley, 2015).

One of the major challenges faced in prisons recently is overcrowding as a result of increase in societal crimes (Aluko *et al.*, 2021; Nweze *et al.*, 2021; Ahmad *et al.*, 2022). Overcrowding and double occupancy of single-occupancy cells are now commonplace, and adding more prisons to make room for them will only result in an increase in the jail population. This method is unlikely to improve the health and wellbeing of inmates (Ismail and Forrester, 2020). A major contributing factor to the overcrowding situation in Nigeria prisons is the high number of offenders awaiting trials who are most times reminded in prison custody pending court ruling (Ahmad *et al.*, 2022). Since the jail does not adequately rehabilitate inmates, Nigerian prisons make little or no contribution to the nation's development (Okwunwanne and Chan, 2020). The development of regular programmes that help the prisoners endure jail can make the time spent behind bars productive. Lack of rehabilitative initiatives also contributes greatly to the increase in prison gangsterism. First-time offenders may become trapped in cycles of poverty, crime, and recidivism as a result of jail sentences and criminal records, and there is frequently no effort made to help them change their ways (Beyrer *et al.*, 2016).

Materials And Methods

The review paper was carried out through the assistance of google scholar by searching and downloading different relevant journals to the research topic, which is, "Nigeria prison reformation! Panacea for reducing recidivism – A case study approach was carried out at Minna Medium Security Prison in Niger State, Nigeria. A structured questionnaire divided into five sections centred on overcrowding, state of the prison, reformative facilities, knowledge on reformation and preferred reformative services were distributed. Out of 185 questionnaires distributed, 120 were returned and were analyzed using tables in Microsoft word. A staff of the prison assisted in the interpretation of the questionnaire to inmates who could not read nor understand the information needed from them. In addition, literatures were reviewed to identify the causes of recidivism, purpose of prisons, effects of prison conditions on inmates, overcrowding in prison, benefits of inmates' reformation and reformation programmes and services for inmates.

Previous Studies

Causes of Recidivism

The stigmatization of released prisoners and their denial of public housing, welfare benefits, food stamps, student loans, and employment chances are some factors that contribute to recidivism (Adegboyega, 2020). Recidivism sets into the lives of inmates when the conditions of the prisons are not reforming and or conducive to bring a change of character for inmates. You cannot train a man for freedom under conditions of captivity. The capacity of prison facilities being exceeded, prisoners not receiving the minimum amount of space required by human rights standards, the incidence of disease rising, and the challenge of managing prisons safely and effectively are a few issues related to prison facilities (Ajayi *et al.*, 2019).

Recidivism may result from prisoner depression, which is frequently brought on by inactivity and poor living conditions. In general, depression is shown to be 45.5% and 56.4% more common among inmates in Ethiopia, 19.2% more common in Norway, 57.4% more common in Turkey, and 72.6% more common in Nigeria (Bedaso *et al.*, 2020).

Purpose of Prisons

The primary goal of creating prison institutions around the world, including Nigeria, is to offer a rehabilitation and correctional facility for people who have disobeyed social norms (Akpojaro and Omogbhemhe, 2017). Desistance from crime is the primary goal of a prison sentence, and support is a crucial component of that desistance. Desistance is a term used to describe stopping criminal activity. But this "termination" of crime does not take place immediately. Instead, desistance is a progression from times when there are no crimes to the point at which normal law-abiding behaviour can resume (Scalpello, 2022). This period of achieving desistance can best be achieved in a secluded environment from where the crimes are likely to be committed and that is the prison.

The objective of prison facilities is to provide a safe and respectable environment for inmates to live in while they are incarcerated and after they are released, as well as for everyone else who has a connection to the prison area (Ajayi *et al.*, 2019). As a social institution for the administration of criminal justice, prisons serve two basic, functional functions: they house prisoners and provide custody for individuals awaiting trial or in detention (Melvin, 2013). Anyone imprisoned is a punishment aimed at correcting a wrong done. Although a contentious part of the contemporary jail system, the rehabilitation of inmates has long been important. Indeed, the religious (Christian) leaders who initially established the penitentiary, the western equivalent of the prison, aimed to reform the offender by a harsh administration that included theological edifying (Akunesiobike, 2016).

Effects of Prison Conditions on Inmates

There are also hints that certain elements of the living situation while in custody affect the likelihood of criminal behaviour after custody. Even after being released from jail, many criminals in several African countries return to crime and harass the community despite receiving vocational training in carpentry, electrical work, shoemaking, etc. As a result, the financial situation in the prisons gets worse (Akunesiobike, 2016). This majorly occurs as a result of the conditions in prison which is usually debated by some stakeholders as a place solely meant to punish offenders. The safety and well-being of inmates, employees, and the safe administration of penal institutions can all be impacted by a humane living environment. Research on male, female, and juvenile detainees has shown that elements like fair treatment by staff, frequent visits from family or friends, the number of hours of activity, the nature of the day program, and positive interactions with fellow detainees are associated with fewer instances of misconduct and psychological issues among prisoners (Garman *et al.*, 2020). An essential requirement for the process of stopping new crimes is the ability to learn and make decisions.

Overcrowding in Prisons

Overcrowding is a major problem facing Nigeria Prisons. The bulk of inmates in Nigeria jail system are awaiting trial inmates and those of the remand groups. "The level of investigation in the lower courts is so shoddy; convictions are happening on no evidence", "The defendants are disadvantaged people who cannot buy their way out of the criminal justice system, or influence the actors in the system." (Burki, 2021). There are numerous instances in Nigeria where prisons have replaced homes for rehabilitation with training grounds for criminals. The population that enters and leaves Nigerian jails suggests that there are systemic issues, which is why the prison system has not been able to fulfill its expected role in Nigeria (Obioha, 2011).

Benefits of Inmates Reformation

A few nations, such as the United States and Canada, substitute the words "corrections" and "correctional reform" for "penal system" and "penal reform." Custody, parole, and probation are all included in the term "corrections," but whether a state calls its criminal justice system "correctional" no longer indicates how much of an emphasis it places on rehabilitation(Ogwezzy, 2011).

Fundamentally, rehabilitation is a tool used to avoid recidivism which is the tendency or possibility of inmates or convicts to commit other crimes and offences or similar ones for which reason they have been punished. This occurs when the inmates remain the same persons they were before confinement or they become worse than they were when freedom is granted unto them and returned into the society.

Reformation Programmes and Services in Prisons

Carriers of reformation through which the aim of reformation could be achieved are referred to as reformation facilities and services. These facilities include workshops! For skills acquisition programmes which are mainly in carpentry, tailoring, printing and masonry. Others are shoeing making shops, furniture making, metal fabrication, soap making, aluminium and ceramic works.

Services through which inmates can be reformed are classified as recreational, religious and counselling services. The recreational activities are football, volleyball, table tennis, indoor games among others.

Prisoners are an essential target audience for sporting events because incarceration is linked to psychological anguish, anxiety, and a generally low quality of life (Obadiora, 2016). Compared to the time when formal education initiatives were elusive in the global prison service, prison education has made a greater contribution to lowering recidivism and the employability of recently released convicts (Adeyeye, 2019).

Results And Discussions

Overcrowding of Prison

Poor judicial system majorly contributes to overcrowding in the prisons. Kuje prison in Abuja witnessed a riot in 2007 as a result of overcrowded inmates. As at May 2018, Makurdi prison houses over 900 inmates against the original capacity of 240 inmates. From the respondents, delay in the dispensation of justice by the courts is the major cause of overcrowding in the prisons. From the table below, 65.8% of the respondents which is the highest strongly agree that delay in hearing of cases in courts majorly contributes to prison overcrowding while 29.2% agreed to it. 2.5% of the respondents were not sure of the causes of overcrowding in prisons and 1.67% of the respondents disagreed with court delays as the cause of overcrowding. Only 0.83% strongly disagreed.

Table 1: Causes of Overcrowding in Prisons

Judicial System Contributes to Overcrowding in Prisons.	Frequency	Percent (%)	Cumulative Percent (%)
Strongly Disagree	1	0.83	0.83
Disagree	2	1.67	2.5
Not Sure	3	2.5	5.0
Agree	35	29.2	34.2
Strongly agree	79	65.8	100.0
Total	120	100.0	

State of Minna Medium Security Prison

Recidivism sets into the lives of inmates when the conditions of the prisons are not reforming and or conducive to bring a change of character for inmates. You cannot train a man for freedom under conditions of captivity (Jordan, 1989). An evaluation of Minna Medium Security Prison from the inmates, wardens and other prison officials indicates that 41.7% of the respondents said that the prisons are very un-conducive for inmates while 40.0% said the prisons are un-conducive for prisoners. 10% of the respondents were not sure of the prison conditions and 5% claimed the prisons were conducive. Finally, 3.3% were of the opinion that the prisons were very conducive for offenders.

Table 2: State of Minna Medium Security Prison

State of Prisons.	Frequency	Percent (%)	Cumulative Percent (%)
Very Un-conducive	50	41.7	41.7
Un-conducive	48	40.0	81.7
Not Sure	12	10.0	91.7
Conducive	6	5.0	96.7
Very Conducive	4	3.3	100.0
Total	120	100.0	

Knowledge of Inmates Reformation

The demand for individual's rights becomes more effective when such individual knows his rights. The knowledge of the provision for reformation of prisoners is scarce and limited. Most of those imprisoned do not know they have such rights. From the table below, 26.7% of respondents are poorly knowledgeable on inmate's reformation while 40.8% which is the highest percentage do not know that prisoners need reformation. 14.1% are highly knowledgeable on the provisions for inmate's reformation and 11.7% of the respondents have knowledge on the need to reform inmates. 6.7% were not clarified of the information required of them.

Table 3: Knowledge of Inmates Reformation

State of Prisons.	Frequency	Percent (%)	Cumulative Percent (%)
Very Un-conducive	50	41.7	41.7
Un-conducive	48	40.0	81.7
Not Sure	12	10.0	91.7
Conducive	6	5.0	96.7
Very Conducive	4	3.3	100.0
Total	120	100.0	

Influence of Reformation on Inmate's Lives

Some inmate's offences and crimes are as a result of idleness or joblessness. When such inmates get into the prison and undergo any of the reformative services, they come out a different person with skills. The table below indicates responses from correspondents on the influence of reformation on the lives of inmates. The table below shows results of how respondents view the influence of reformation on inmate's lives. 7.5% of the respondents believe that reformation has no influence on the lives of inmates, 10.0% says reformation has very low influence on the lives of inmates, 2.5% of respondents were undecided on the influence of reformation on the lives of inmates, 28.3% believe that reformation highly influences the lives of inmates while 51.7% believe that reformation influence on the lives of inmates is very high.

Table 4: Influence of Reformation on Inmate's Lives

Reformation Influence on lives of Inmates.	Frequency	Percent (%)	Cumulative Percent (%)
No Influence	9	7.5	7.5
Very Low Influence	12	10.0	17.5
Undecided	3	2.5	20.0
High Influence	34	28.3	48.3
Very High Influence	62	51.7	100.0
Total	120	100.0	

Preferred Reformation Services by Inmates

There are several services that are aimed at making the lives of inmates better after they have served their respective jail terms. Some of the available service in the sampled prisons includes educational services, skills acquisition services, counselling services, religious services and recreational services. The inmates prefer one reformative service to the other and they believe that their lives will definitely be better off when given hose trainings. Table 5 below shows results of how inmates prefer one reformation service to another. 6.7% of the respondents believe that educational services can reform inmates, 35.0% which represents the highest preferred skills acquisition services to reform inmates, 26.7% of the inmates showed interest in counselling, 20.0% believe in religious services to reform inmates while 11.6% preferred recreational services as tool to reform inmates.

Table 5: Influence of Reformation on Inmate's Lives

Reformation Services for Inmates.	Frequency	Percent (%)	Cumulative Percent (%)
Educational	8	6.7	6.7
Skills	42	35.0	41.7
Counseling	32	26.7	68.4
Religious	24	20.0	88.4
Recreational	14	11.6	100.0
Total	120	100.0	

Conclusion

Prisons serve as medium of correction for offenders confined to them for a period of time. The confinement in itself is a punishment since freedom is restricted or reduced to minimum. After such period of confinement, the individuals are allowed back to the society for their normal life. Whether those released from prison are better or worse is a function of the life lived in prison.

For a prisoner to return back into the society a better person, there are some basic requirements that will help to rehabilitate or reform such persons. From the prisons studied, there are no rehabilitative facilities in most of them and where they exist, they are inadequate, outdated or deteriorated. Also, the absence of these facilities makes the prisoners feels like captives not worthy to be rehabilitated. Finally, the inmates on the waiting trial are more than those convicted which overcrowded the prisons.

Recommendations

1. Reformation facilities should be the fundamental basis of prison designs and construction.
2. The judiciary should be reformed to facilitate dispensation of justice. This reform could be in the creation of separate courts to handle criminal cases. And the courts for the purpose of criminal cases should be located within the prisons as this will facilitate quick dispensation of justice on criminal cases.
3. More attention should be given to prisoner's reformation than punishment. Except in a capital offence, all prisoners should be given the opportunity to be rehabilitated since they will definitely return to the society.
4. General awareness should be made on reformation of inmates especially to the inmates in the prison. This will enhance people's knowledge on inmate's reformation.
5. Construction of new prisons across the zones will help to reduce the number of prisoners in the congested prisons.

References

Adegboyega, L. O. (2020) 'Predisposing Factors of Recidivism as Perceived by Prison Officers in Kwara State, Nigeria: Implications for Counselling Practice', *Mimbar Pendidikan*, 5(1), pp. 1–14.

Adeyeye, B. A. (2019) 'Challenges and Prospects of E-Learning for Prison Education in Nigeria', *European Scientific Journal ESJ*, 15(25).

Ahmad, S., Aborode, A. T., Lateefat Oluwatomisin, S., Abai Sunday, B., Faderin, E., Agboola, P., Adebusuyi, O., Karra-Aly, A. and Oguibe, G. F. (2022) 'Children in detention amidst COVID-19 in Africa: A wound untreated', *Annals of Medicine and Surgery*. Elsevier Ltd, 81(July), p. 104217.

Ajayi, O. O., Faremi, O. J. and Adenuga, O. A. (2019) 'Physical Conditions of Prison Facilities in Southwest, Nigeria: Prison Staff Perspective.', *The Lagos Journal of Environmental Studies*, 10(1), pp. 48–60.

Akpojaro, J. and Omogbhemhe, M. I. (2017) 'a Conceptual Design of Information System', *Asian Journal of Mathematics and Computer Research*, 15(2), pp. 131–140.

Akunesiobike, C. A. (2016) 'The Role of Religious Groups in Offender Reformation: A Study of the Port Harcourt Prison in Rivers State, Nigeria', *Journal of Pan African Studies*, 9(10), p. 104.

Aluko, O. O., Esan, O. T., Agboola, U. A., Ajibade, A. A., John, O. M., Obadina, O. D. and Afolabi, O. T. (2021) 'How secured and safe is the sanitation and hygiene services in a maximum-security correctional facility in Southwest Nigeria: a descriptive cross-sectional study', *International Journal of Environmental Health Research*. Taylor & Francis, 00(00), pp. 1–18.

Bedaso, A., Ayalew, M., Mekonnen, N. and Duko, B. (2020) 'Global estimates of the prevalence of depression among prisoners: A systematic review and meta-analysis', *Depression Research and Treatment*, 2020.

Beyrer, C., Kamarulzaman, A. and McKee, M. (2016) 'Prisoners, prisons, and HIV: time for reform', *The Lancet*. Elsevier Ltd, 388(10049), pp. 1033–1035.

Burki, T. (2021) 'The death penalty continues unabated globally', *Lancet (London, England)*. Elsevier Ltd, 397(10284), pp. 1531–1532.

Emasealu, H. U. (2019) 'Attitude of inmates towards the prison library', *Brazilian Journal of Information Science: research trends*, 13(2), pp. 78–91.

Garman, G., Weijts, W., Douw, F., Keukens, R., Liausedas, A. and van Voren, R. (2020) 'Reforming prison mental health services in Ukraine', *Forensic Science International: Mind and Law*. Elsevier Ltd, 1(January), p. 100011.

Ismail, N. and Forrester, A. (2020) 'The state of English prisons and the urgent need for reform', *The Lancet Public Health*. The Author(s). Published by Elsevier Ltd. This is an Open Access article under the CC BY 4.0 license, 5(7), pp. e368–e369.

Melvin, A. O. (2013) 'Prison health in Nigeria: A sociological discourse', 7(May), pp. 38–41.

Nwaopara, U. and Stanley, P. (2015) 'Prevalence of depression in Port Harcourt Prison', *African Journal of Psychiatry (South Africa)*, 18(6).

Nweze, V. N., Anosike, U. G., Ogunwusi, J. F., Adebisi, Y. A. and Lucero-Prisno, D. E. (2021) 'Prison health during the COVID-19 era in Africa', *Public Health in Practice*. Elsevier Ltd, 2(January), p. 100083.

Obadiora, A. H. (2016) 'The influence of sport participation on quality-of-life perceptions among inmates in Nigerian prisons', *Journal of Sport for Development*, 4(August 2016), pp. 36–43.

Obioha, E. E. (2011) 'Challenges and Reforms in the Nigerian Prisons System', 27(2), pp. 95–109.

Ogwezzy, M. C. (2011) 'From reformation to deformation: an approach towards sustainable development of the defective prison system in Nigeria', *journal of sustainable development in Africa*, 13(7), pp. 269–283.

Okwunwanne, U. and Chan, G. K. L. (2020) 'Prison Gangs for Prison Life Survivability: Exploring the Reasons for Prison Gang Formation in Kiri-Kiri Maximum Security Prison', *e-BANGI*, 17(5), pp. 26–46.

Rao, G. R. S., Minhat, H. S., Shahar, H. K., Mukhtar, F. and Anusuyah (2019) 'Prevalence and socio-demographic determinants of depression among inmates of a prison in Malaysia', *Online Journal of Health and Allied Sciences*, 18(2), pp. 1–7.

Scalpello, M. (2022) 'Surviving in a small island state prison. Analysing prison officer support and assistance as narrated by people in prison', *International Journal of Law, Crime and Justice*. Elsevier Ltd, 70(May), p. 100545.

Incorporating Principles of Adaptability in Spatial Configuration to Enhance Spatial Requirement in the Design of General Hospital Suleja, Niger State

Isiaka, A. S.[1], Maina, J.J. [2a], Salihu, M.M. [2b], Saliu, O.H. [2c].
[1]*Department of Architecture Federal University of Technology Minna, Niger State.*
[2]*Department of Architecture Ahmadu Bello University Zaria, Kaduna state.*
[a]Isiaka.ahmadu@futminna.edu.ng; [b]jjmaina@abu.edu.ng; [c]murtalasg@gmail.com; delozove16@gmail.com
corresponding author: Isiaka.ahmadu@futminna.edu.ng

Abstract:

This paper is aimed at defining the life cycle of a hospital and how easy they adapt to change by meeting different uses, allowing various spatial and functional configurations, and updating technologies which are responsible for the frequent changes in facility, changes in functional spaces and upgrading of entire hospital building without necessary affecting the day-to-day activities of the facility usage. Using a pilot study in Amadu Bello University Zaria medical centre in Kaduna state there has been comparatively less attention paid to establishing generic variables for general hospital design in Nigeria. A total of 15 key variable were established from literature. A checklist was generated and filled by four professionals from the built environment to ascertain objective result, and two professionals from the facility were interviewed from a structured interviewed question, to further triangulate the methodology an Autodesk software was used to remodel the plans of the facility and plates where taken. Result revealed that little or no attention was paid on adaptable design principle in healthcare building, followed by the established fact that design shapes adopted in some of the building pose a serious challenge to the facility and the floor to ceiling height of the building is too small and does not reflect that of a health care building, modular grids were seen to be absent in the core part of the building. The study has been able to demonstrate the relevance of adaptable design to healthcare buildings. There is a need to adopt flexibility as a design strategy to accommodate the change that comes with time and save cost in constructing and expanding Nigerian healthcare buildings.
Keywords: *Adaptability, Spatial Requirement, flexibility, Principle.*

Introduction

Adaptable healthcare building is a term used in architecture to describe the built-in ability to adapt and adjust to change, by meeting different uses, allowing various spatial and functional configurations, and updating technologies without requiring significant disruption of the building (Kronenburg, 2007). Adaptability plays a major role in providing a building's sustainable attributes, and the possibility of enduring through time while the building spaces and components continue to change over time, which is included as one of the pillars of sustainable development (Nakib, 2010a). Hospital buildings are complex structures because of their articulation, function, spatial organization and technological equipment, (Buffoli, Nachiero, & Capolongo, 2012). Furthermore, planning hospitals requires an interdisciplinary approach in order to efficiently organize the construction of qualitative and adaptable units. Architecture has special characteristics which should enable adaptability with the development patterns of needs that occur within it (Indrawan, Faqih, & Purnomo, 2012).

Recently research in the healthcare sector in Nigeria is moving towards highly technologically structural and functional adaptable systems, (Adedokun, 2016; Olumide, 2012; Union & Migration, 2014). Numerous studies on technical, organizational and management guiding principles for the construction of high-tech assistance hospitals devote considerable space to the issue of adaptability to guarantee high quality over time through the design of spaces that can be adapted to the growing new needs of hospital development, (Fara, 2011; Verderber, 2000).

However, few studies establish flexibility strategies for medical school in Nigeria, (Wakil, 2018). Nevertheless, little or no research have been conducted on adaptability strategies in hospital design in Nigeria.

Methodology

This study employs both qualitative and quantitative approaches to data collection, reviews of relevant literature and Interviews of key management staff was carried out to ascertain if the design is adequate and satisfied. The facility for case study and visual survey was selected based on expandability, complexity, infrastructure, region and years of active operation, to determine the spaces and their configuration. An Autodesk software was used to model the floor plans to show the visibility, connectivity and integration within the built environment. Plates were used to show current state of the facility, visual survey was also carried out to derive activity charts in order to ascertain spatial configurations and relationships of spaces. The variables for checklist were derived from an in-depth literature review are: structural grid, adaptation (building form), interstitial spaces, ceiling height, location of vertical transport, location electrical and mechanical services, transformation (method of construction), accessibility, interaction (spatial organisation), flexibility, and convertibility.

Flexibility and Adaptability

There is a growing understanding that space and place means a lot to productivity (Larssen, 2016). It is unequivocal to know that adaptability and flexibility has been used interchangeably, scholars have noted that some researchers and architects use "flexibility" for physical changes and "adaptability" for non-physical changes, (Estaji, 2017). The study also proposed a distinction between these two terms; he defined "adaptability as capable of different social uses and flexibility as capable of different physical arrangements'' Conclusively it is genuine to say adaptability is the ability of the built environment to support multiple functions without altering the architecture of the building, and to accommodate changes of use or function, which result in the need to alter the building and its services tangibly or organisationally, (Barlow et al, 2009).

Historical Review of Adaptability in Architecture

Kim (2013), opined that Since Modern Movement, adaptability and flexibility has been one of the most attractive words in architecture. In 1954, Walter Gropius insisted that architecture needs to be flexible enough to contain "the dynamic features of modern life." Forty, (2000) as cited in (Kim, 2013). In order for modern architecture to serve the contemporary society, it must embrace and respond to the state of constant transfer, exchange, relocation and adaptation to new theories and principles (Acharya, 2013). The dynamic features of modern life come with changes that affect the spaces we live inn and work with, and it uses in our daily activities affect our productivity and perception to life.

Adaptability Strategies for Hospital Design

Appropriate architectural design of healthcare facilities plays a substantial role in efficient healthcare delivery by integrating changing requirements of healthcare from time to time. (Babbu, 2016). The study further states that it provides an opportunity to the organization to cope with the future changes in terms of technological advancement of equipment's, improvement in the method of delivery of care, operational changes and address issues related to increase of footfall in the hospital. Since, these changes are evident and accurate prediction is not possible, therefore, healthcare designers should consider the future adaptability as one of the important criteria for design. (Cohen & Barach, 2008). Architectural components that contribute towards making adaptable healthcare design which need special attention of the architects and built environment professionals (Babbu, 2016). Below are the key variables to adaptable healthcare buildings.

Structural Grid

Structural grid is a systematic planning and arrangement of columns and beams to support the superstructure. A column grid of 7.2 meters' x 7.2 meters as earlier mentioned by (Nakib, 2010b). seems suitable for healthcare facilities.

Ceiling Height

Ceiling height of 3.6 meters' floor to floor heights have been kept for all the spaces except operating rooms. 4.0 meters is preferably to avoid any costly structural modification at later stage (Babbu, 2016).

Location of vertical transportation systems

The location of lifts, staircases, ramps is advisable to be located in the service core considering future expansion criteria.

Location of Electrical, Mechanical and other hospital services

Location of this services by provision of "soft spaces" adjacent to these facilities, are also advisable so that they may accommodate the increasing demand of services in the future without disturbing the existing facilities.

Open Building Concept

Open Building concept is a flexible system where floor plans of the hospital buildings are generated based on total gross area of the project without the internal layout. The floor space is divided into number of quadrants by suitable structural grid. One quadrant means the space between four columns

Interstitial Space

Interstitial space is walkthrough space provided between two regular consecutive floors. It is fully accessible space, created to accommodate different services of the hospital. By providing interstitial floors in the hospital especially in hospital laboratories, operating rooms, intensive care unit areas, the rearrangement of these facilities during their lifecycle is easier and hence lifecycle cost will be reduced.

Accessibility

to describe making spaces accessible for all concerning stages of life and various special physical conditions (Lifetime Homes, 20013).

Babbu, (2016), wrote a journal on 'flexibility": A key concept in Hospital Design' with some recommendation. (Mackie, William 1963) which was reviewed by Richard Sprow, (2017) emphasis on incorporating adaptability and flexibility as key strategy in hospital. By looking at the characteristics of the changes proposed in the literature reviewed, it is inevitable to conclude that the flexibility and adaptability are needed to be incorporated in general hospital's design.

Case study

The Ahmadu bello university medical centre (ABU medical centre) was built in 1952 by the Nigerian College of Arts and Science take care of the health needs of the university community on the main campus but was occupied in 1968, (The University Health Services Directorate, Ahmadu Bello University, Zaria, 2018). The present location of the facility is adjacent to Suleiman Hall, and it covers a total area of over 2,600 square meters.

From 1968 to presence the facility has undergone several upgrading. The movements and the expansions of the facility had been necessitated by the need to create a more conducive space to cope with rising demand for the healthcare services as the institution's population is rapidly growing, (The University Health Services Directorate, Ahmadu Bello University, Zaria, 2018). An appreciation of this rising demand may be gained from the fact that in 1972 the facility had attended to an estimated average of 350 cases on daily basis, this figure had gone up to 500 by 1982 and 700 by 1987 and 700-1000 in 1997 to 2002 to present day. However, is became obvious that the facility wasn't built to accommodate the change of time and change in of spaces that will come with increase population of in the future. Current statistics has shown the significant population of the staff and students has significantly increase with the facility facing upgrading and introduction of different wings.

Plate 1: Google map image of Ahmadu Bello University Zaria, Sick-Bay Samaru Campus.

*Plate 2: **image of ABU. Zaria, medical centre***

*Plate 3: **image of ABU. Zaria, medical centre***

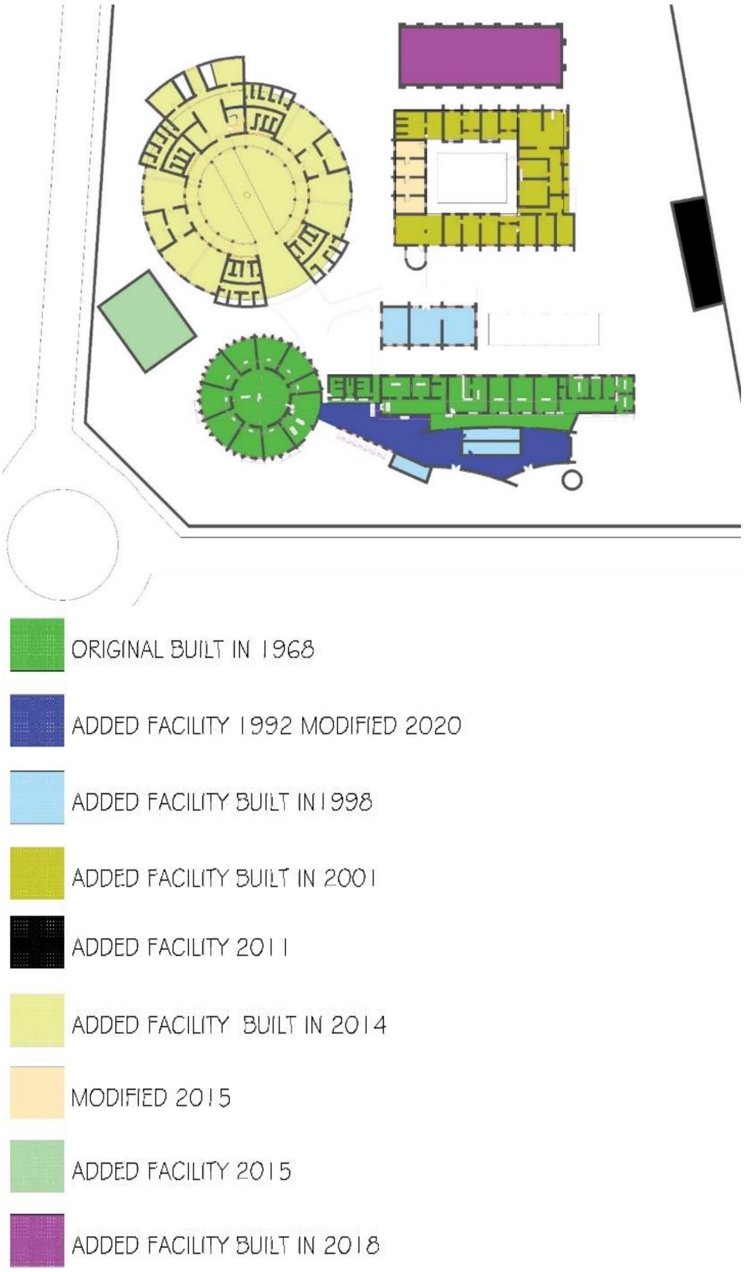


Plate 4: Image of Ahmadu Bello University Medical Centre. Zaria Samaru Campus Floor Plan.

Table 24: Reflection of adaptable design principles as they reflect the checklist from 1 -5, where 1= absence, 5 very high as seen below.

Sn	**Variable**	**Area/Location/ Space/ Building Block**	**Year Of Modification**	**Extent of Modification**	**Remarks (level of reflection)**				
					1	**2**	**3**	**4**	**5**
1	Structural Grid	Consultation, offices, library, records. Injection, pharmacy, waiting, pay point. Laboratory. Lab, dental, haematology, scan. Malignance unit. Wards. Conference room, offices. Mosque. New block.	1968 2020 1998 2001 2011 2014 2015 2015 2018	Minimal on consultation room, pharmacy, waiting area, pay point as the building shape does not allow good structural grid. Maximum in laboratories		✓			

2	Adaptation (Building form)	Consultation, offices, library, records. Injection, pharmacy, waiting, pay point. Laboratory. Lab, dental, haematology, scan. Malignance unit. Wards. Conference room, offices. Mosque. New block.		196820201998200120112014201520152018	Very absence almost all spaces as the facility shaper does not conform to adaptable building form.		✓			
3	Interstitial spaces	Consultation, offices, library, records. Injection, pharmacy, waiting, pay point. Laboratory. Lab, dental, haematology, scan. Malignance unit. Wards. Conference room, offices. Mosque. New block.		19682020199820012011201420	Absences in all spaces.	✓				

				1520152018						
4	Ceiling Height	Consultation, offices, library, records. Injection, pharmacy, waiting, pay point. Laboratory. Lab, dental, haematology, scan. Malignance unit. Wards. Conference room, offices. Mosque. New block.		196820201998200120112014201520152018	Very low ceiling hight is observed in all the property which is against the 3.3meter hight.		✓			
5	Location of vertical trans	Consultation, offices, library, records. Injection, pharmacy, waiting, pay point. Laboratory. Lab, dental, haematology, scan. Malignance unit. Wards. Conference room, offices. Mosque. New block.		196820201998200 1	minimal attention was seeing regarding this variable		✓			

	port			2011 2014 2015 2015 2018						
6	Location of electrical and mechanical services	Consultation, offices, library, records. Injection, pharmacy, waiting, pay point. Laboratory. Lab, dental, haematology, scan. Malignance unit. Wards. Conference room, offices. Mosque. New block.		1968 2020 1998 2001 2011 2014 2015 2015 2018	Electrical services were scattered round the places. Mechanical lavatories are scarce and scanty withing the premisses		✓			

7	Transformation (Method of construction)	Consultation, offices, library, records. Injection, pharmacy, waiting, pay point. Laboratory. Lab, dental, haematology, scan. Malignance unit. Wards. Conference room, offices. Mosque. New block.		196820201998200120112014201520152018	Traditional block and lintel were predominant in the facility.		✓			
8	Accessibility	Consultation, offices, library, records. Injection, pharmacy, waiting, pay point. Laboratory. Lab, dental, haematology, scan. Malignance unit. Wards. Conference room, offices. Mosque. New block.		19682020199820012011201420	Located in the heart of the university and its easily accessible to all intended users.			✓		

				15 2015 2018						
9	Interaction (Spatial organization) (Spatial sequencing)	Consultation, offices, library, records. Injection, pharmacy, waiting, pay point. Laboratory. Lab, dental, haematology, scan. Malignance unit. Wards. Conference room, offices. Mosque. New block.		1968 2020 1998 2001 2011 2014 2015 2015 2018	Open parking lots are the only visible spaces with interaction spaces. Special sequencing is only visible on the laboratories.		✓			
10	Flexibility	Consultation, offices, library, records. Injection, pharmacy, waiting, pay point. Laboratory. Lab, dental, haematology, scan. Malignance unit. Wards. Conference room, offices. Mosque. New block.		1968 2020 1998	Very minimal at all spaces	✓				

				200120112014201520152018						
11	Convertibility	Consultation, offices, library, records. Injection, pharmacy, waiting, pay point. Laboratory. Lab, dental, haematology, scan. Malignance unit. Wards. Conference room, offices. Mosque. New block.		196820201998200120112014201520152018	Absence at all spaces.	✓				

12	Foldable/collapsible walls	Consultation, offices, library, records. Injection, pharmacy, waiting, pay point. Laboratory. Lab, dental, haematology, scan. Malignance unit. Wards. Conference room, offices. Mosque. New block.		196820201998200120112014201520152018	Absence at all spaces.	✓				
13	Modular grid	Consultation, offices, library, records. Injection, pharmacy, waiting, pay point. Laboratory. Lab, dental, haematology, scan. Malignance unit. Wards. Conference room, offices. Mosque. New block.		19682020199820012011201420	Visible in the added facility that was built in 2001,		✓			

				1520152018						
14	Spatial Organisation	Consultation, offices, library, records. Injection, pharmacy, waiting, pay point. Laboratory. Lab, dental, haematology, scan. Malignance unit. Wards. Conference room, offices. Mosque. New block.		196820201998200120112014201520152018	Minimal in most spaces, but visible in the old consultation room.			✓		

Visual Survey Checklist Data Presentation and Analysis

Demographic of the respondents is presented on the table below:

Table 25: Checklist Respondents Demographics

	1	2	3	4
GENDER	*Male*	*Male*	*Male*	*Male*
AGE	*30-35*	*25-30*	*25-30*	*25-30*
INSTITUTION	*ABU Zaria*	*ABU Zaria*	*ABU Zaria*	*ABU Zaria*
FACULTY	*Env. Design*	*Env. Design*	*Env. Design*	*Env. Design*
DEPARTMENT	*Architecture*	*Architecture*	*Architecture*	*Architecture*
LEVEL	*800/MSc*	*800/MSc*	*800/MSc*	*800/MSc*

Table 26: Visual Survey Checklist, (pilot study).

S/NO	VARIABLE	RATING	REMARKS
1	Structural Grid	20%	There seemed to be little or no structural grid system followed, but rather and architectural grid. The pockets form of the irregular scattered building shows how detached the entire building are from each other
2	Adaptation (Building form)	5%	The curvilinear building forms are not adaptable, not flexible, they are difficult to expand, cost more to build. Buildings sprouting close to the main OPD makes the spatial layout unorganized and can't be easily adaptable.
3	Interstitial spaces	0% Absent	Vertical adaptable features are not present in the entire facility.
4	Ceiling Height	6%	The most used part of the building

			has a very low ceiling height of 2.4 meter, some spaces are 2.0 meters, while the new units (wards and laboratories) are about 3 meters high.
5	*Location of vertical transport*	*20%*	*The facility has a single stair case located in ward the middle with active spaces around which won't be easily linked in an expansion.*
6	*Location of electrical and mechanical services*	*20%*	*The electrical and mechanical services are located at the core part of facilities, where it will be difficult to tap from for expansion of for future use.*
7	*Transformation (Method of construction)*	*39.5%*	*Traditional method of building with block laying with mortar mixture was used, without load bearing frames in the building,*

			Column and beam are exposed in the covered walk ways. It will be difficult to transform
8	*Accessibility*	*49%*	*The main access to the site is from the gate. The facility, however, is very porous.*
9	*Interaction (Spatial organization) (Spatial sequencing)*	*20%*	*The facility shows partial integration* *The poor zoning arrangement of the buildings in the site had affected the sequencing of spaces and brought pockets of building organization (where buildings are treated as individual round and square units).*
10	*Flexibility*	*10%*	*The round concept adapted for the core of the building has limited flexibility.*
11	*Convertibility*	*15%*	*The rigidity of most of the spaces makes it difficult to convert the use or add*

			more use to the spaces.
12	*Foldable/ collapsible walls*	*0%*	*There exist no foldable or expandable walls in the entire facility.*
13	*Modular grid*	*10%*	*The first phase of the facility was designed completely without modular grid. However, the recent additions do.*
14	*Spatial Organisatio n*	*10%*	*The first building was done without the thought of future expansion causing other blocks to be added at different spots on site.*

Results and Discussion

End users of the facilities interviewed on how well is the building situated for healthcare business, where of the view that the facility is centrally located in the university with good proximity to the whole faculty, host community, hostel and staff quarters.

The technical condition of the building was viewed from the inception of its establishment to date, the ideal building concept has gone through series of changes over time, the general outpatient department has changed over time (GOPD). Medical peer review for medical professional shearing patients and technical issues with outmost confidentiality is not tenable here because of the consultation room type.

Series of upgrading done to the facility has really created a serious challenge of ventilation, making the building to be clustered together making it easy for communicable disease to be transmitted.

The response from the question of how well does the building accommodate the growing population of the university, the growing population of the university has posed a serious threat to the service rendered in the facility, a doctor seeing over 70 patients within a short period of hours which possess a serious challenge of quality healthcare system to be delivered. The facility to one of the medical practitioners said the building takes the form of a supermarket in his on view

Vertical growth of the facility will help a long way to increase more space and functions, because horizontal growth is not tenable dew to the fact that the whole system has been chokes all round which will sure affect the ventilation of the facility.

When asked if the building accommodate technological advancement, record keeping is assured to be upgraded to electronical system, but the physical structure cannot accommodate any advance upgrade because of the clumsy and clustered building nature.

Conclusion

Adaptable building forms, modular shape designs and flexible spaces that will accommodate the frequent change that comes with time is best recommended for hospital design, the covid surge has sure given us reason to adhere to these principles for a better and adaptable hospital design.

Interstitial space should be introduced at major units for easy vertical expansion, and plenum space, location of vertical transportation system should be at the core for easy access, electrical and plumbing ducts should be at the edges of the building for easy access to other adaptable issues that might arise from time to time

Linking of consultation rooms in a way were peer-review will be optimized without interference from the GOPD or patients on waiting area seeing the medical professional movement will go a long way in making flexibility tenable in consultation rooms.

References

Ademiluyi, I. A., & Aluko-Arowolo, S. O. (2009). Infrastructural distribution of healthcare services in Nigeria: An overview. Journal of Geography and Regional Planning, 2(5), 104–110. Retrieved from http://www.academicjournals.org/JGRP

Babbu, A. H. (2016). "Flexibility": A key concept in Hospital Design. International Journal of Application or Innovation in Engineering & Management, 5(5), 24–28. Retrieved from http://www.ijaiem.org/Volume5Issue5/IJAIEM-2016-05-11-13.pdf

Buffoli, M., Nachiero, D., & Capolongo, S. (2012). Flexible healthcare structures: analysis and evaluation of possible strategies and technologies. Annali Di Igiene: Medicina Preventiva E Di Comunita, 24(6), 543–552. Retrieved from http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=medl&NEWS=N&AN=23234192

Cohen, U., & Barach, P. (2008). Hospitals and healthcare. Herd, 1(3), 128.

Estaji, H. (2017). A Review of Flexibility and Adaptability in Housing Design. The New Arch, 4(2), 37–49. https://doi.org/10.14621/tna.20170204

Fronczek-Munter, A. (2013). Evaluation methods for hospital facilities. International Journal of Facilities Management Citation (APA International Journal of Facilities Management, 12, 215–226. Retrieved from http://orbit.dtu.dk/files/59511230/Evaluation_methods_for_hospital_facilities.pdf

Habraken, N. J. (1998). Introduction: control and form / The physical structure of the built environment (Ch. 1) / Type (Ch. 17). In The Structure of the Ordinary: Form and Control in the Built Environment (pp. 5–294).

Hareide, P. J., Bjørberg, S., Støre-Valen, M., Haddadi, A., & Lohne, J. (2016). Strategies for Optimization of Value in Hospital Buildings. Procedia - Social and Behavioral Sciences, 226(October 2015), 423–430. https://doi.org/10.1016/j.sbspro.2016.06.207

Id, S., & Count, W. (2016). Integration of user's space needs in the design of general hospitals in nigeria. Iii, R. S., Austin, S., & Gibb, A. (n.d.). What is the Meaning of Adaptability In The Building Industry.

Indrawan, I. A., Faqih, M., & Purnomo, H. (2012). Title Flexibility and Adaptability as Architectural Approach in Designing Hospital, 2(9), 8990–8994.

Kendall, S. (2011). New Challenges for the Open Building Movement: Architecture in the Fourth Dimension. In Proceedings of the Joint Conference of CIB W104 and W110 (pp. 8–13).

Kim, Y. (2013). On Flexibility in Architecture Focused on the Contradiction in Designing Flexible Space and Its Design Proposition - IMPRESSO. Architectural Research, 15(4), 191–200.

Krystallis, I., Demian, P., & Price, A. D. F. (2012). Design of flexible and adaptable healthcare buildings of the future - a BIM approach. Proceedings of the First UK Academic Conference on BIM, Newcastle Business School & School of Law Building, Northumbria University, 5-7 September 2012, 222–232.

Lelieveld, C. M. J. L., Voorbij, A. I. M., Ph, D., & Poelman, W. A. (2007). Adaptable Architecture. International Conference of 21st Century COE Program of Tokyo Metropolitan University, (Adabtibale Building), 245–252. Retrieved from http://tmu-arch.sakura.ne.jp/pdf/26_proc_bsa_e/Proceedings_pdf/245-252 031SS_B2-2.pdf

Mackie, W. (1963). Planning the Hospitals of the Future. The Lancet, 281(7274), 211–213. https://doi.org/10.1016/S0140-6736(63)91228-5

Milano, P. (2015). Adattabilità operativa e progettuale nelle strutture sanitarie, 162–170. https://doi.org/10.13128/Techne-16118

Nakib, F. (2010). Fractal geometry: A tool for adaptability and "evolutionability." WIT Transactions on Ecology and the Environment, 128(April 2010), 39–47. https://doi.org/10.2495/ARC100041

Nakib, F. (2010a). Technological Adaptability, an Approach Toward a Flexible and Sustainable Architecture. Conference On Technology & Sustainability in the Built Environment, 479–494.

Nakib, F. (2010b). Technological Adaptability, an Approach Toward a Flexible and Sustainable Architecture. Conference On Technology & Sustainability in the Built Environment, (November), 479–494.

Nakib, F. (2010c). Toward an Adaptable Architecture Guidelines to integrate Adaptability in the Building. CIB 2010 World Congress Proceedings: Building a Better World, 276–286.

Nascimento, D. M. (2012). N. J. Habraken explains the potential of the Open Building approach in architectural practice. Open House International.

Olumide, A. (2012). Journal of Sustainable Development in Africa (Volume 14, No.1, 2012). Sustainable Development in Africa, 14(1), 185–201.

Pena, M. M., & Melleiro, M. M. (2012). Degree of satisfaction of users of a private hospital. Acta Paulista de Enfermagem, 25(2), 197–203. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=ccm&AN=108137408&site=ehost-live&scope=site

Rao, S. K. M. (2004). Designing hospital for better infection control: An experience. Medical Journal Armed Forces India, 60(1), 63–66. https://doi.org/10.1016/S0377-1237(04)80163-1

Salingaros, N. A. (2000). Hierarchial cooperation in architecture and the mathematical necessity for ornament. Journal of Architectural and Planning Research, 17(3), 221–235.

Sorensen, B. S., Zane, R. D., Wante, B. E., Rao, M. B., Bortolin, M., & Rockenschaub, G. (2011). WHO - Hospital Emergency Response Checklist. World Health Organization, 1–26. Retrieved from http://www.euro.who.int/__data/assets/pdf_file/0008/268766/Hospital-emergency-response-checklist-Eng.pdf

Union, E. (EU), & Migration, I. O. for (IOM). (2014). "Promoting Better Management of Migration in Nigeria" Needs Assessment Of Nigerian Education Sector By International Organization For Migration ,. Report, (May), 0–62.

Wall, B. M. (1998). History of Hospitals. American Statesman. Retrieved from http://www.nursing.upenn.edu/nhhc/Welcome Page Content/History of Hospitals.pdf

Ascertaining Daylighting Wastage in the College of Engineering Complex, Najran University, Saudi Arabia

Bal-Harith, H.M.[1a], Abdul Karim, A.N.[1b], Alotaibi, B.S.[1c], Abuhussain, M.A.[1d], Qahtan, A.M.[1e]& Dodo, Y.A.[1f]

[1]*Architectural Engineering Department, College of Engineering, Najran University, Najran, 66426, Kingdom of Saudi Arabia.*

Corresponding author: yadodo@nu.edu.sa

Abstract:

The amount of natural light used in buildings has a big impact on how much energy is used there. The requirement for or use of artificial light can be reduced to lower the energy consumption of a commercial facility. The study tries to identify daylight wasted in the college of engineering, Najran University due to a lack of policy implementation and daylight technology utilization for lighting at the design stage with an abundance of daylighting available in the region. This study result is based on a Likert scale questionnaire administered to selected members of the college and observation adapted from Patton (1986) on a pilot scale. The result shows that 60% of the respondents agree daylight applications can help in conserving energy, although there was no technological approach to harvest the huge amount of daylight available in addition 40% of the respondents agree that daylighting codes are not enforced in the kingdom but mentioned in the MOSTADAM and LEED which are the most rating system used for certification of green building in Saudi Arabia. Although the pilot study recorded a low Cronbachs' Alpha of 0.56, it is glaring that an ample amount of daylight is wasted in the university that could be harvested to conserve energy usage via retrofitting the college; this will in turn save the cost of energy usage for lighting, reduce carbon dioxide emissions and as well enhance sustainability

Keywords: Ascertain, Daylighting, Wastage, College, Engineering, Najran. University, Saudi-Arabia

Introduction

The amount of natural light used in buildings has a big impact on how much energy is used there. The requirement for or use of artificial light can be reduced to lower the energy consumption of a commercial facility. By producing more light for less heat than artificial light, natural light is more energy-efficient than electrical light. For instance, a tungsten lamp creates between 5 and 14 times more heat than sunlight at a given level of intensity (Baker and Steemers, 2000). As a result, daylight also reduces a building's cooling needs by up to 15% (Muhs, 2000). Any decreases in the amount of power used for lighting and cooling can ultimately have a negative impact on the environment due to the current heavy reliance on fossil fuels for electricity generation and the reduced output of greenhouse gases. The impact on people's health and well-being is one outcome of this change that has not yet been completely realized. Additionally, the operation of these structures necessitates a significant amount of power and, consequently, fossil fuels for lighting and air conditioning, which ultimately contributes to the emission of greenhouse gases. It is now widely acknowledged that anthropogenic greenhouse gas emissions have a significant role in global warming (Intergovernmental Panel on Climate Change, 2001). In order to reduce reliance on energy for lighting and maximize the use of natural light, particularly in deep-plan structures, one of the tenets of green architecture is to: the total energy use of the structure. In addition to increasing the visual appeal of buildings, adopting daylighting as an illumination source also has positive effects on occupants' productivity and health. The parts that follow go into greater detail about the advantages of daylighting in structures, the issue with deep-plan buildings, and the many daylighting options that are available for these structures, as well as their uses. Therefore, this study is to ascertaining if there is daylighting wastage in the college of engineering complex Najran University Saudi Arabia at a pilot scale.

Background

College of Engineering, Najran University

The largest university in Saudi Arabia is Najran University, a public institution of 18 km2 that has two main campuses and is gender-segregated. The university has a lot of facilities as well (e.g., administrative buildings, support deanships, a university hospital, sports and entertainment centers, public school buildings, and housing for students and faculty members). In order to carry out the goals of its programs, which were developed in accordance with the most recent international standards, and to adhere to the standards of the Saudi National Center for Academic Accreditation and Evaluation (NCAAE) and the American Accreditation Board for Engineering and Technology, the College makes an effort to provide an integrated learning environment (ABET). By outfitting classrooms with the most cutting-edge educational tools, teachers may provide their students the chance to study in a variety of ways. Figures 1 and 2 depict an aerial perspective and a typical floor plan of the engineering college at Najran University. In their analysis, Qahtan, Ebrahim, and Ahmed (2020) determine that the annual lighting energy savings was 43856.6 kWh/year while the daily electrical lighting energy savings for the atrium space and connected corridors at the first and second levels was 121.82 kWh/day. The 25 colleges at Najran University collectively save 1096380 kWh annually. The overall cost savings, however, amount to around (93,512.86) USD. The overall cost savings, however, amount to around (93,512.86) USD. On the campus of Najran University, it is highlighted that there are still opportunities to minimize energy use in the university buildings by retrofitting the lighting control system in additional atriums and courtyards.

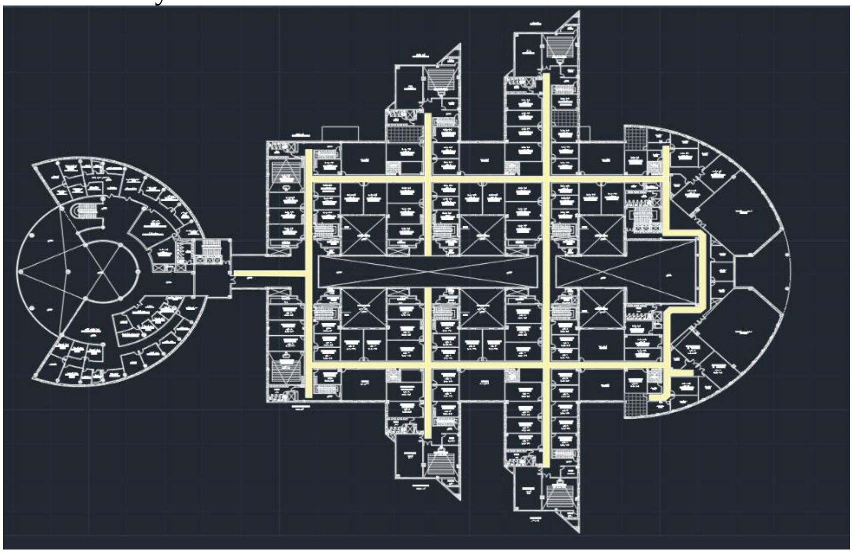


Figure 1: A Typical Floor Plan of the College of Engineering

Figure 2: Aerial view of college of Engineering, Najran University

Availability of Daylight from Najran Sky

Southwest Saudi Arabia's Najran is a city with coordinates of 17°29′30″ N and 44°7′56″ E. The average monthly temperature of Najran City, which has a desert climate, ranges from 17°C in the winter to 45°C in the summer. According to Mansour, Sawalha, and Salem (2013), Saudi Arabia is the second sunniest country in the world, and Najran is one of the Saudi cities with the highest daily solar radiation at more than 6.9 kwh/m2/day (Zell, et. al., 2015). According to figure 3, Najran City receives more than 3600 hours of sunlight annually, or 10 sunny hours on average every day. The average number of hours of sunshine per month varies from 357 from April to August to 260 from the remaining months of the year. Moreover, Table 1 shows the Najran City cloud cover, with an average peak below 20%. According to the CIE standard, a clear sky is one that has fewer than 30% of clouds present, while a cloud-sky is one that has more than 70% of clouds present (IESNA, 2000). As a result, Najran City enjoys clear skies all year round (Qahtan, Ebrahim and Ahmed 2020).

Month	Jan	Feb.	Mar.	April	May	June	July	Aug.	Sep.	Oct	Nov.	Dec.
Sun Hours	230	260	315	372	386	375	374	372	346	301	225	231
Global Horizontal Irradiance Wh/m2	229	268	285	294	317	322	295	300	294	285	246	222
Cloud cover %	1	16	10	5	3	2	17	15	1	0	2	1
CIE Overcast range %	≥ 80											

***Figure 3**: Average monthly sunlight hours, Global Horizontal Irradiance and cloud cover of Najran City. Adopted from (Qahtan, Ebrahim and Ahmed 2020)*

Direct sunlight on a clear day can provide illuminance levels of up to 100 000 lux at midday, making daytime in a clear and sunny sky situation difficult (Frank, Doug, Jeff, & Josh, 2014). In a climate like that, daylighting is connected with drawbacks including glare and higher cooling loads. The difficulty is in managing daylight such that it is used without glare and the heat is kept out (Yilmaz, 2016). Further complicating the investigation of the daylight component linked to the worst sky state of the overcast sky is the fact that Najran City has clear and sunny skies year-round. In this study, the daylight illuminance in Najran City under a clear sky will be studied and discussed (Qahtan, Ebrahim and Ahmed 2020).

Daylighting Wastage

By mere observation one can see that, with the availability of daylight in a clear and sunny sky condition like that of Najran, illuminance levels of up to 100 000 lux at midday can be realize (Qahtan, Ebrahim and Ahmed 2020) whit such amount of daylight available the corridors should be devoid of artificial lighting except when necessary (when the lux level is lower than that that will allow any task to be perform and at night when daylight can't be harvest)

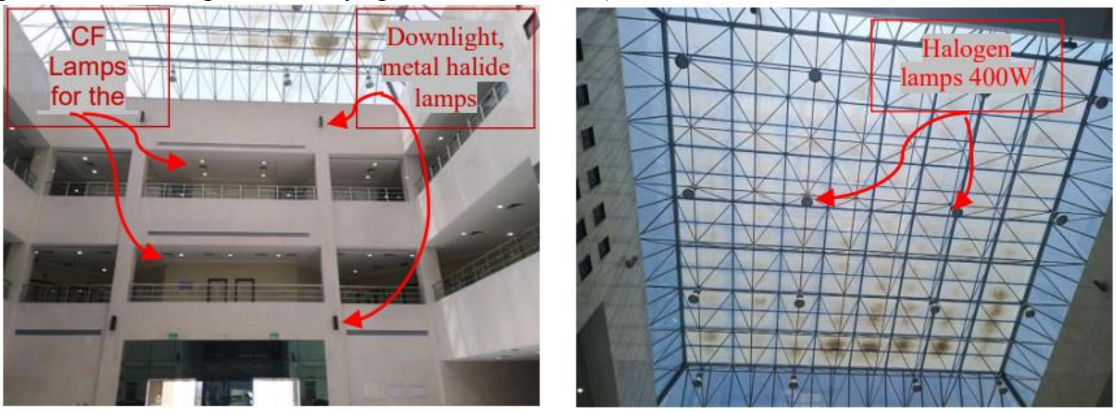


***Figure 4**: Interior view of showing daylight Wastage at College Engineering adopted from (Qahtan, Ebrahim and Ahmed 2020)*

Reasons for Daylighting in Buildings

According to Goulding, Lewis, and Steemers, (1994), there are expenses involved with optimizing daylight lighting in buildings, thus it's critical to comprehend the justifications for doing so. Which are: 1) Natural light is superior to electrical light in terms of illuminating quality, spectrum composition, and variety. Electrical light does not produce the same sensation for the human eye as does natural light, which is why it has evolved to respond to it.

2) Daylighting has psychological and physiological advantages over artificial lighting and windowless structures that may help people perform better.
3. When solar energy is used to offset the demand for electricity during the day's peak hours, energy efficiency is improved.
4) A long-term, sustainable outcome Lower reliance on non-renewable energy sources and increased reliance on solar and sky radiation can lead to (i.e., reduced greenhouse gas emissions).
5) Energy savings and improved workplace health raise the rental price or worth of the facility. Additionally, daylighting can be marketed as a selling point

Method

The method uses in this study consist of a mixed method utilizing available secondary data [existing document] (Saunders, Lewis, & Thornhill, 2012 and Creswell, 2009) to come up with set of questions which were administer to selected the Najran faculty of engineering users and was complimented by a direct observation of lighting usage in the faculty. The questionnaire Consists of 4 parts and 11 questions, it pilot study Potentials of Fiber Optic Daylighting Systems in the Hot Arid Climate of Saudi Arabia: a Case Study of Najran University College of Engineering Corridors, and in order to carry out this research a pilot scale was conducted to determine the awareness technology and policy on daylighting harvesting of the research this was administered to 4 responders. Direct observation has been used in this research as one of the utmost and effective approaches for gathering accurate information. This method of gathering data entails the researcher visit a location with the assistance of a checklist, and observing the scene, and recording occurrences as they are seeing Table 1 for the methodological process employed.

Table 1: Methodology and Data Analysis Techniques Employed the Study

<table>
<tr><th>Research objectives</th><th>Proposed method</th><th>Proposed Analysis</th></tr>
<tr><td rowspan="3">To identify lighting [Artificial and Daylight] usage pattern in the college</td><td>a. <u>Existing documents</u> (secondary data) (secondary data) from Journals and handbooks (Saunders, Lewis, and Thornhill, 2012).</td><td>The use of thematic analysis; Guest, MacQueen, and Namey (2012)</td></tr>
<tr><td>b. <u>Administering Questionnaire</u></td><td>Using SPSS to analyse</td></tr>
<tr><td>c. <u>Direct Observation</u></td><td>Identifying, coding, and analysing (recurrent)</td></tr>
</table>

Observation is therefore constituted of a dimensional framework within which an elaborate combination of permutations can be adopted depending on the objectives and aim of a researcher as well as the type of research and condition of elicited data. One of the observational frameworks Figure 5, which was submitted by Patton (1990) and was adapted in this study.

Results and Discussion

Most respondents agree that there is wastage of daylight with 60% strongly agreeing and 40% agreed, while, regarding technology 60% strongly agreeing and 40% agreed that there is no daylighting dynamic system used in the design of the college of Engineering buildings. Policy is one the most important aspect, if it is in place then both awareness and technology would be easily assimilated, unfortunately, only 20% of the respondents are aware of lack of daylighting legislation in the kingdom. Although there was no technological approach to harvest the huge amount of daylight available in addition 40% of the respondents agree that daylighting codes are not enforced in the kingdom but mentioned in the MOSTADAM and LEED which are the most rating system used for certification of green building in Saudi Arabia.
Although the pilot study recorded a low Cronbachs' Alpha of 0.56, it is glaring that an ample amount of daylight is wasted in the university that could be harvested to conserve energy usage via retrofitting the college
Observation is therefore constituted of a dimensional framework within which an elaborate combination of permutations can be adopted depending on the objectives and aim of a researcher as well as the type of research and condition of elicited data. One of the observational frameworks Figure 2, which was submitted by Patton (1990) and was adapted in this study. Figure 7 show various points of observation that shows the potential of harvesting daylight in the college of engineering buildings.

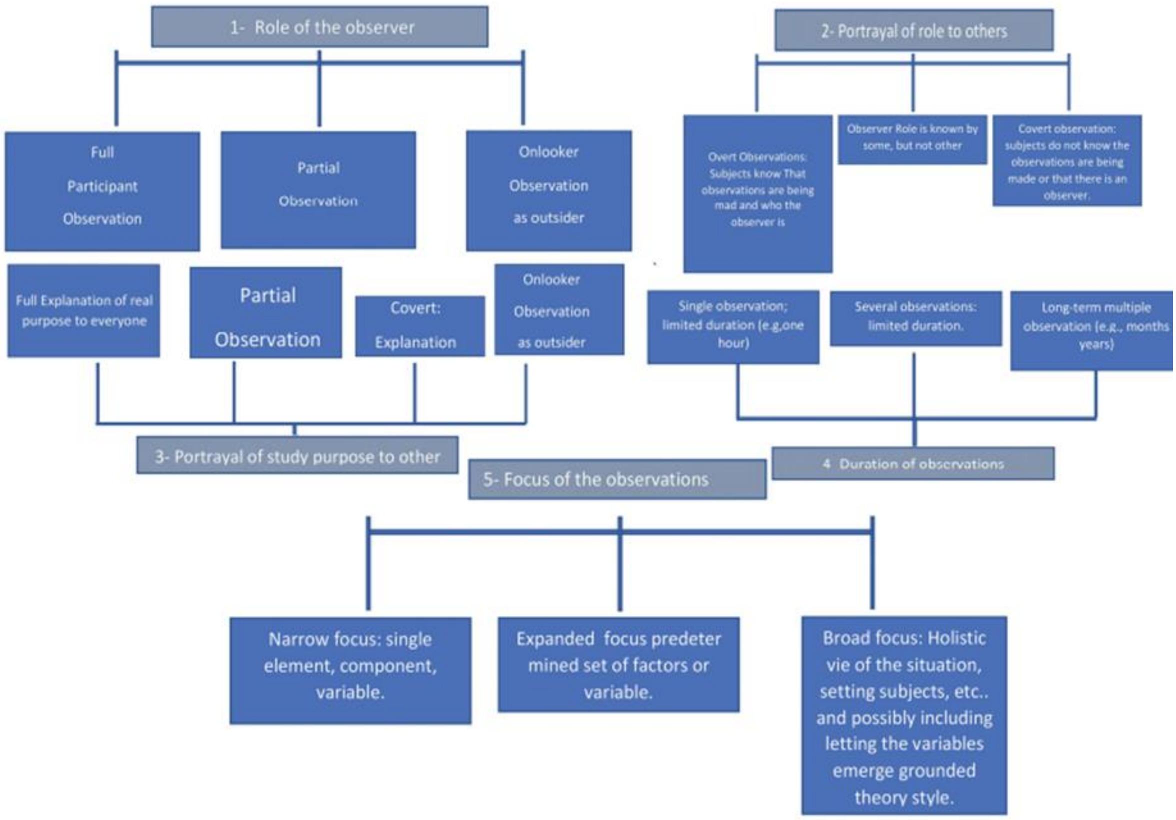


Figure 5: The Study Observational Frameworks Adapted From Patton (2002)

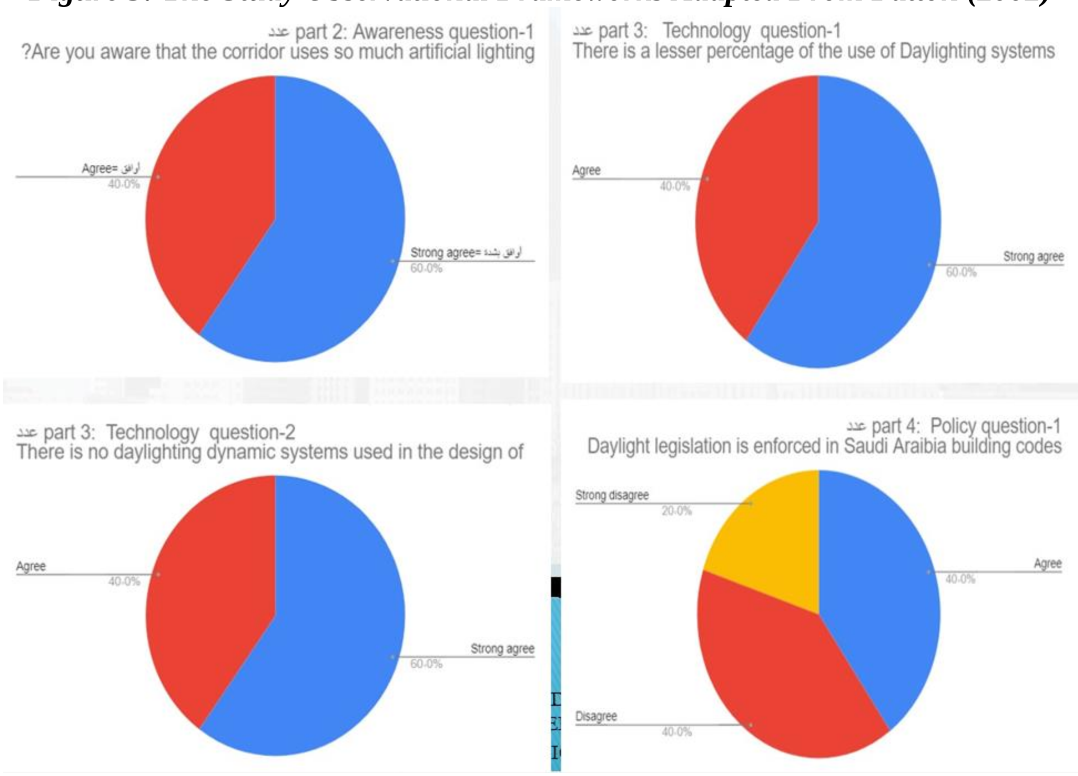


Figure 6: The study observational frameworks adapted from Patton (2002)

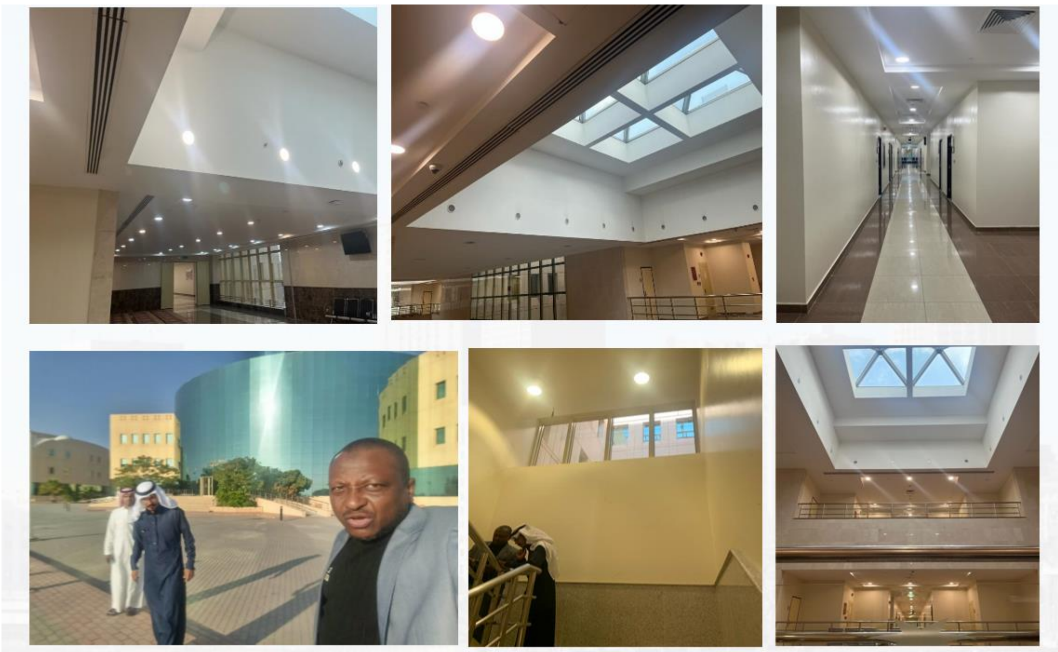


Figure 7: Observation carried out and information gather with recommendation

Discussion

The study identifies daylight wasted in the college of engineering, Najran University due to a lack of policy implementation and daylight technology utilization for lighting at the design stage with an abundance of daylighting available in the region. This study result is based on a Likert scale questionnaire administered to selected members of the college and observation adapted from Patton (1990) on a pilot scale. The result shows that 60% of the respondents agree daylight applications can help in conserving energy, although there was no technological approach to harvest the huge amount of daylight available in addition 40% of the respondents agree that daylighting codes are not enforced in the kingdom but mentioned in the MOSTADAM and LEED which are the most rating system used for certification of green building in Saudi Arabia. Although the pilot study recorded a low Cronbachs' Alpha of 0.56, it is glaring that an ample amount of daylight is wasted in the university that could be harvested to conserve energy usage via retrofitting the college; this will in turn save the cost of energy usage for lighting, reduce carbon dioxide emissions and as well enhance sustainability.

Conclusions

The result shows that 60% of the respondents agree daylight applications can help in conserving energy, although there was no technological approach to harvest the huge amount of daylight available in addition 40% of the respondents agree that daylighting codes are not enforced in the kingdom but mentioned in the MOSTADAM and LEED which are the most rating system used for certification of green building in Saudi Arabia. Although the pilot study recorded a low Cronbachs' Alpha of 0.56, it is glaring that an ample amount of daylight is wasted in the university that could be harvested to conserve energy usage via retrofitting the college; this will in turn save the cost of energy usage for lighting, reduce carbon dioxide emissions and as well enhance sustainability.

Although, the result is from the pilot study carried out, but it's certain that day lighting is wasted in the college and this might be confirmed in the full study carried out.

Acknowledgements

The authors would like to thank the University of Najran for supporting this project.

References

Baker, N. and Steemers, K. (2002) Daylight Design of Buildings, James & James, London.British Standard Institute (2007) BS OHSAS 18001:2007 Occupational health and safety management systems - Requirements. London: British Standard Institute.

Creswell, J.W. (2009) Research design: qualitative, quantitative, and mixed method approaches, 3rd edition. California: Sage Publications.

Frank, S., Doug, L., Jeff, D., & Josh, C. (2014). The Use And Environmental Impact Of Daylighting. Journal of Cleaner Production. 85: 462-471. doi: https://doi.org/10.1016/j.jclepro.2014.03.092

Goulding, J. R., Lewis, O. and Steemers, T. C. (1994) *Energy in Architecture. The European Passive Solar Handbook*, B.T. Batsford Limited for the Commission of the European Communities, London.

Guest, G.M, MacQueen, K.M. and Namey, E.E. (2012) Applied Thematic Analysis, Thousand Oaks, California: SageIESNA, (2000). The IESNA Lighting Handbook. New York: Illuminating Engineering Society of North America.

Intergovernmental Panel on Climate Change (2001) Climate Change 2001: Synthesis Report. Wembley, United Kingdom. Intergovernmental Panel on Climate Change.

Mansour, T. A., Sawalha, S., & Salem, N. (2013). A Mathematical Model for Solar Assisted Automobile A/C Based on Absorption Refrigeration System. International Journal of Mechanical Engineering (IJME). 2(4): 75-86

Muhs, J. D. (2000) Design and Analysis of Hybrid Solar Lighting and Full-Spectrum solar energy systems, Proceedings of American Solar Energy Society "Solar2000 Conference", Madison, Wisconsin.

Patton, M. Q. (1990) *Qualitative evaluation and research methods (pp. 169-186). Beverly Hills*, CA: Sage.

Qahtan, A. M., Ebrahim, D. A., and Ahmed, H. M. (2020) Energy-Saving Potential of Daylighting in the Atria of Colleges in Najran University, Saudi Arabia International Journal of Built Environment and Sustainability IJBES 7(1)/2020, 47-55

Saunders, M., Lewis, P., and Thornhill, A. (2012) Research methods for business students. 6th edn. London: Pearson.

Yilmaz, F. Ş. (2016). Proposal of a Façade Design Approach for Daylight Performance Determination In Buildings. A|Z ITU Journal of the Faculty of Architecture. 13(2): 57-64.

Zell, E., Gasim, S., Wilcox, S., Katamoura, S., & Stoffel, T. (2015). Assessment of Solar Radiation Resources in Saudi Arabia. Solar Energy, 119, 422-438. https://doi.org/10.1016/j.solener.2015.06.031

Evaluation of Daylighting Conditions in Public Libraries: A Case Study of Kaduna, Nigeria

Ojobo, H.[1a], Tachio, A.[1b], Boyle, G.M.[1c] & Chindo, M.[1d]
[1]*Department of Architecture, Faculty of Environmental Science, Kaduna State University, 801139, Kaduna, Nigeria*
[a]henry.ojobo@kasu.edu.ng: [b]adtachio@gmail.com: [c]gaiya.malachy1@gmail.com:[d]martin.chindo@kasu.edu.ng
Corresponding author: henry.ojobo@kasu.edu.ng

Abstract:

Proper lighting controls integrated with daylighting have a strong potential for reducing energy demand in non-domestic building by exploiting daylight more effectively. The cost of energy nowadays and the diminishing resources necessary to generate energy have resurrected the need for daylight in buildings and the sun once again can be revered as a source of life and energy. The introduction of innovative, advanced daylighting strategies and systems can considerably reduce a building's electricity consumption and also significantly improve the quality of light in an indoor environment. The aim of this study therefore is to evaluate the adequacy of daylighting conditions in public libraries through the case study of selected libraries in Kaduna State Nigeria. The case study research method was used to study and understand library buildings so as to evaluate the lighting system in them. Through field survey, data was collected using observation, physical measurements, photographs and checklist. It was observed that the conditions in the libraries studied have relatively poor daylight design necessitating the use of artificial lighting fixtures especially during the day. It was also noted that the use of electric light fixtures is only limited to particular hours of the day and under cloudy sky situations. Therefore, the daylight approaches in public libraries needs to be modified as they tend to reduce the dependence on artificial lighting and building's energy consumption.

Keywords: Daylighting, Library, Energy, Indoor Environment.

Introduction

Daylight possesses the very special characteristics of having the ability to transform an internal space from uninspiring uniformity into a psychological uplifting experience. Day lighting is also an effective approach in creating a pleasant visual environment and a useful source of energy savings in commercial buildings (Daryanani, 1984). The amount of daylight entering a building is mainly through window openings that provide the dual function not only of admitting light for indoor environment with a more attractive and pleasing atmosphere, but also allowing people to maintain visual contact with the outside world. Daylight varies in intensity and quality from moment to moment and how much variation is desirable or can be tolerated will depend on the particular use of a space (Boubekri *et al*., 2003). Lighting requirements can be very strict for certain uses, for example in museums and libraries but are more flexible in many applications.

Artificial lighting is one of the major electricity-consuming items in many non-domestic buildings, accounting for about 20–30% of the total building energy load. There has been an increasing interest in incorporating daylight in architectural and building designs as a means to reduce energy use in buildings. Proper lighting controls integrated with daylighting have a strong potential for reducing energy demand in non-domestic building by exploiting daylight more effectively (Li and Lam, 2001). Throughout history, daylight has been a primary source of lighting in buildings, supplemented originally with burned fuels and more recently with electrical energy (Aderemi, et al, 2009). Before daylight was supplemented or replaced with electric light in the late 19th-century, consideration of good daylight strategies was essential.

According to Kilic and Hasirci (2011), Libraries before the start of light technology were characterized by volumes and planes illuminated with daylight, no glare lighting in reading spaces. Wong (2017) further noted that any building design that takes adequate thought for daylight is considered a good design, due to the ambience of quiet contemplation and visual comfort created. This is why a properly lit work place promotes psychological sensations of comfort and enables quick understanding, with increase in productivity. The use of daylight came with problems in terms of glare and solar heat gain and so it became easier to shut it out of buildings and replace it with electric lighting, which was cheap and easy to control then (Lee et al, 2019). Due to the increasing cost of energy and the depletion of resources needed for its generation, there has been a renewed recognition of the importance of daylight in buildings, and the sun is once again being revered as a source of life and energy (National Research Council, 2010)

The introduction of innovative, advanced daylighting strategies and systems can considerably reduce a building's electricity consumption and also significantly improve the quality of light in an indoor environment (Freewan and Dalala, (2020). This study tends towards the exploration of daylight quality in library buildings through the case study of daylight design strategies in the admittance of useful daylight for the purpose of energy savings and to enhance visual task and reading. The aim of this study therefore is to evaluate the adequacy of daylighting conditions in public libraries through the case study of selected libraries in Kaduna State Nigeria.

Methodology

The case study research method was used to study and understand library buildings so as to evaluate the lighting system in them. The analysis of the various components of each building was based on the research variables. These variables are used to create a checklist that is used on the field survey. The selected cases were selected due to their inherent qualities which are in line with the study area, they include; National Library Kaduna and Kafanchan Library. A field survey and visual survey of cases was done by looking and identifying what has been achieved by the already existing libraries with reference to elements that allow natural light into the work space and reading areas and this was done by the use of photographs and checklist as guide for getting the needed data. Data collected on this research was documented and presented on case study assessment tables to show relationships between variables.

Data Presentation and Discussion

Case Study 1: National Library Kaduna

Background

National Library Kaduna is located along Yakubu Gowon road in Kaduna State. It was established in 1986, as a Public Library and funded by the Federal Government of Nigeria. It serves as the nation's intellectual data store house and helps government officers in connecting to policies and help in the implementation of same. The National Library is the country's largest depository of knowledge, collecting publications both from Government, and private authorities The state falls within the tropical climatic zone; it is located between latitudes 9 08' and 11 07'N and longitudes 6 10' and 8 48'E, with a land mass of about 45,567 square kilometres. Kaduna State occupies a major position in the agricultural economy of Northern Nigeria and the site is characterized by mostly clear sky in day time and this permits longer hours of sunshine. The average duration of sunshine varies from 6.0 to 9.8 hours.

Plate I: Main entrance (NLK)

Site planning and general building concept

The site Plan in Figure 1 below shows the library building oriented towards the southwest and having a plentiful setback off the access road at the main entry. According to Albatayneh, et al. (2018), an appropriate building orientation will allow the desirable winter sun to enter the building and allow ventilation in summer by facing the summer wind stream. A southern orientation results in a little solar gain and heat losses through the window in winter. Hence orientation criterion is a factor to be determined when designing a more economical building in terms of thermal and energy optimization. The building is about 890m2 in area. It is made of reinforced concrete frame, glass and steel.(Daryanani, 1984)

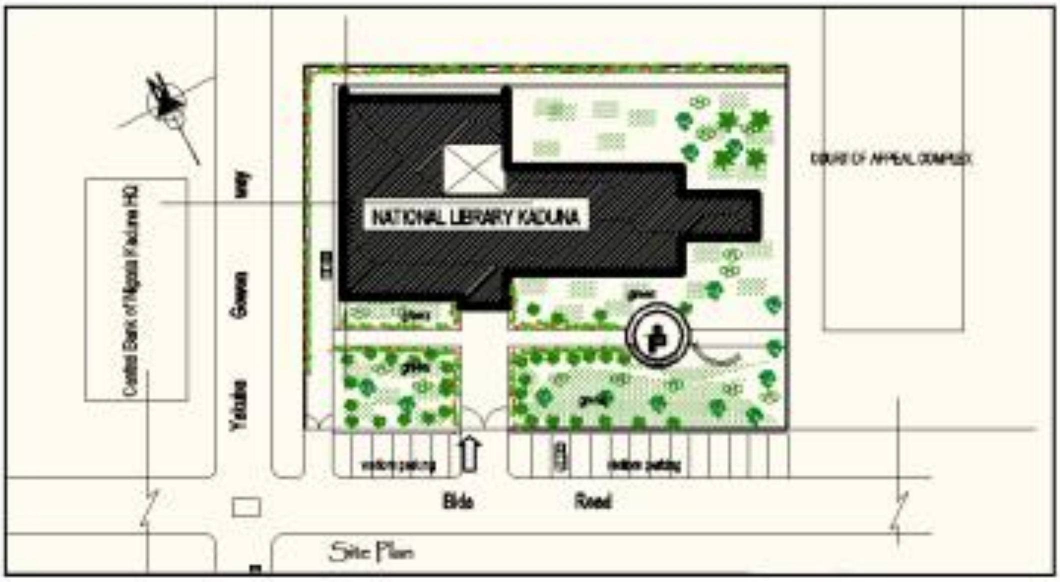


Figure 1: Site plan (NLK)

In Plate I above, it shows the main entrance made up of prefabricated concrete and glassed aluminium doors and windows. The roof is covered with aluminium-zinc, with no provision for roof lighting.

Plate II: Sun Shading element (NLK)

In Plate II Sun shading screen wall is adapted on the western façade over daylight apertures to minimize direct sun ray and allow in useful daylight.

Spatial organization and space allocation

Having entered the building; you meet the reception/security hall and an exhibition area from where the other units of the building are being accessed. Figure 2 (Ground floor), houses the reception/control, exhibition hall, main library hall (reference stack and reading area), staff common room, e-library, offices and conveniences. Figure 3 (First floor) is linked from the ground floor by stair cases on the east and west ends of the structure contains the serial section, a seminar/holding room, kitchen, a conference hall, office and Conveniences.

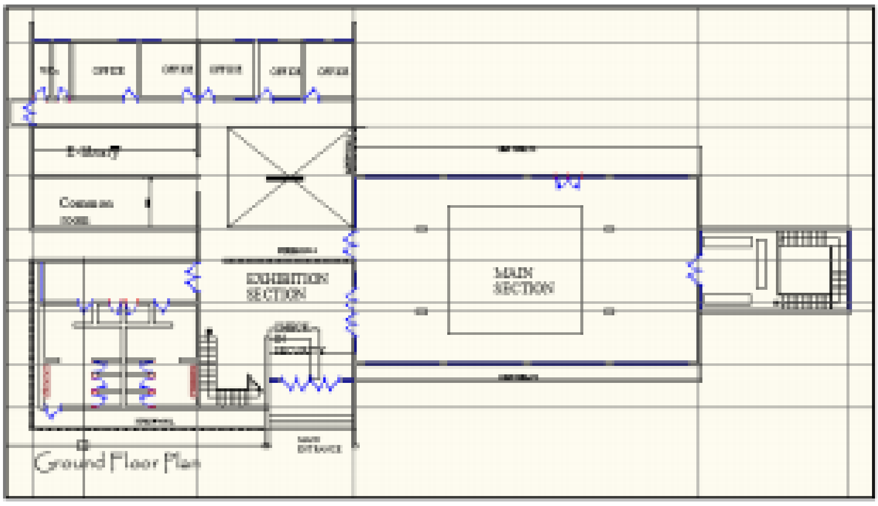


Figure 2: Ground floor plan (NLK)

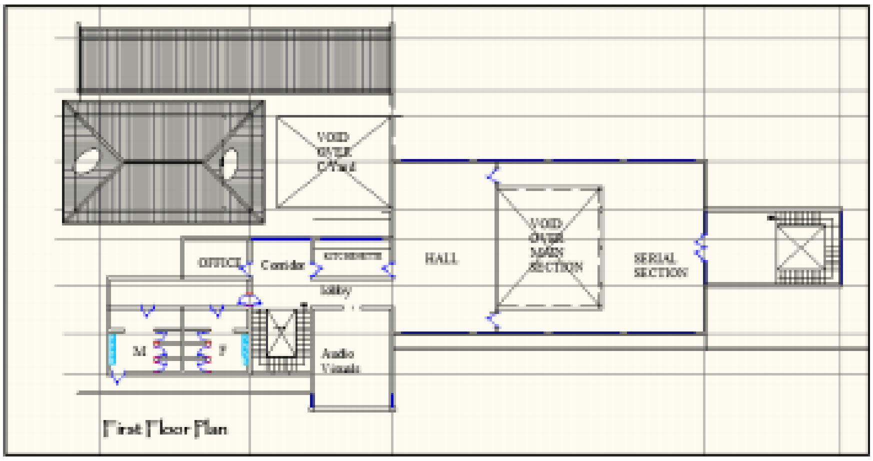


Figure 3: First Floor Plan (NLK)

Daylight Strategy adopted

The passive control of sunlight is properly used in relation to the building orientation on site. A strategy in passive design of building envelope which can be applied in order to reduce the external heat gain in buildings is shading elements usage. Solar radiation adjustment which enters into a building is a major step in passively cooling process to get thermal comfort condition (Faisal and Aldy, 2016). From Plate II and Plate III, the shading elements adopted on the south west helps to reduce solar heat gain, glare and also diffuse the sunlight intensity into the adjourning space as useful daylight. A Court yard is also used to admit daylight and air into the building. Incorporating Courtyards into buildings improves energy efficiency by enhancing daylighting condition within the interior spaces (Aldawoud and Clark, 2008). Large transparent sliding windows that are both effective for daylight and aeration are employed.

Access to windows with ample daylight and external views is advantageous to the occupants and will affect their satisfaction with the workspace (Yildirim et al., 2007). The void over the main reference section at the ground floor also allows useful daylight on that floor. The ceiling is made of white colour 600mm x 600mm gypsum board. The buildings shape and configuration are also noted as a good design strategy for daylight harvest.

Plate III: Right end of the main entrance (NLK)

Table 27: Variables studied in National Library, Kaduna

S/N	Space	Variables	Observation	Remarks
1	Main reading area (ground floor)	Room geometry and orientation	Rectangular, with longer sides facing east and west	Direct sunlight, glare and heat gain eminent
		Area, arrangement of daylight object	2.8 X 4.6 meters side light aluminium sliding window	Good window head height
		Position and size of internal barriers	Stack areas are properly zoned to allow for useful daylight	Do not cause obstruction
		Position and size of external barriers	They are not close to openings	Do not cause obstruction
		Shading for openings	The east/west ends are properly shaded with screen wall and overhangs	Effectively shaded
		Glazing property	Clear glass	Good transmittance
		Sky condition	Overcast mostly	Cloudy depending on season of the year
2	Government Archives	Room geometry and orientation	Rectangular, and glazed which the shorter sides are facing north and south	Direct sunlight, glare and heat gain contained through orientation
		Area, arrangement of daylight object	3.5 X 3.6 meters side light aluminium sliding window	Good window head height
		Position and size of internal barriers	Stack areas are properly zoned to allow for useful daylight	Do not cause obstruction
		Position and size of external barriers	They are not close to openings	Do not cause obstruction
		Shading for openings	Ends are properly shaded with screen wall	Effectively shaded
		Glazing property	Clear glass	Good transmittance
		Sky condition	Overcast mostly	Cloudy depending on season of the year
3	Serial/reference section	Room geometry and orientation	Rectangular with longer side facing the east and west	Direct sunlight, glare and heat gain eminent
		Area, arrangement of daylight object	1.5 X 4.6 meters side light aluminium sliding window	Good window head height

		Position and size of internal barriers	Stack areas are properly zoned for useful daylight	Do not cause obstruction
		Position and size of external barriers	They are not close to openings	Do not cause obstruction
		Shading for openings	Aluminium louvers and screen walls	Effectively shaded
		Glazing property	Clear glass	Good transmittance
		Sky condition	Overcast mostly	Cloudy season of the year

Case Study 2: Kafanchan Library

Background

The library is located along Emirs palace of Kafanchan and it was established in 1975, as a public library and funded by the Kaduna state government. The state falls within the tropical climatic zone; the site is characterized by mostly clear sky in day time and this permits longer hours of sunshine. The average duration of sunshine varies from 6.0 to 9.8 hours.

Site planning and general building concept

The building is oriented towards the north-east on site with 2meters setback from the road leading to the Emirs palace. Its structure is made up of Reinforced Concrete Frame, wood, glass, there are no roof lighting.

Spatial Organization and space allocation

The children library is just along the south wards shown in the fig (4) below while the main building is north of the children library. The main library is made up of 2 reading area, lending section, reference section and administrative section which include staff room, officer in charge, principal librarian, Assistant Librarian.

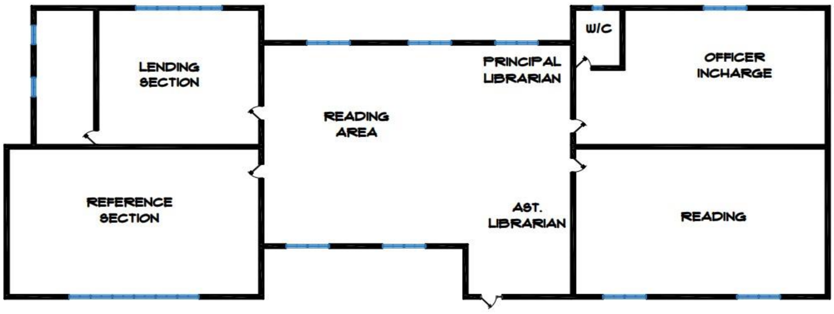


Figure 4: Floor Plan of Kafanchan Library

Daylight Strategy

The passive control of sunlight was properly used in relation to the building orientation on site. From Table 2, the observed variables indicate that the room geometry and orientation of the main reading area is rectangular with the longer side facing east west direction.

As a result, direct sunlight, glare and heat gain is eminent within the space. This is also similar to what is obtainable at the reference section of the library. Conversely, room geometry and orientation of the reading section of the library is rectangular, and glazed with the shorter side facing north south direction. A study by Morrissey, Moore, and Horne (2011) show that building orientation plays an important role in passive solar design. The main benefit of the building orientation is the energy efficiency with regards to lighting, heating and cooling cost. In addition, building orientation is a low-cost alternative to maximize passive solar benefits, which will result in the reduction of energy use.

Table 28: Variables studied in Kafanchan Library, Kaduna

S/N	SPACE	VARIABLES	OBSERVATION	REMARKS
1	Main reading area	Room geometry and orientation	Rectangular, with longer sides facing east and west	Direct sunlight, glare and heat gain eminent
		Area, arrangement of daylight object	1.2 X 3.6 meters side light aluminium sliding window	average window head height
		Position and size of internal barriers	Stack areas are properly zoned to allow for useful daylight	Do not cause obstruction
		Position and size of external barriers	They are not close to openings	Do not cause obstruction
		Shading for openings	The windows are shaded with overhang of 100mm	poorly shaded
		Glazing property	Clear glass	Good transmittance
		Sky condition	Overcast mostly	Cloudy depending on season of the year
2	Reading Section	Room geometry and orientation	Rectangular, and glazed which the shorter sides are facing north and south	Direct sunlight, glare and heat gain contained through orientation
		Area, arrangement of daylight object	1.2 X 2.4 meters side light aluminium sliding window	average window head height
		Position and size of internal barriers	Stack areas are properly zoned to allow for useful daylight	Do not cause obstruction
		Position and size of external barriers	They are not close to openings	Do not cause obstruction
		Shading for openings	The windows are shaded with overhang of 100mm	poorly shaded
		Glazing property	Clear glass	Good transmittance
		Sky condition	Overcast mostly	Cloudy depending on season of the year
3	Reference section	Room geometry and orientation	Rectangular with longer side facing the east and west	Direct sunlight, glare and heat gain eminent
		Area, arrangement of daylight object	1.2 X 2.4 meters side light aluminium sliding window	average window head height
		Position and size of internal barriers	Stack areas are properly zoned for useful daylight	Do not cause obstruction
		Position and size of external barriers	They are not close to openings	Do not cause obstruction
		Shading for openings	The windows are shaded with overhang of 100mm	Poorly shaded
		Glazing property	Clear glass	Good transmittance
		Sky condition	Overcast mostly	Cloudy season of the year

As shown in Plate VI, the shading strategy of solid window edges and the use of fixed light over projected windows also helps admit daylight and aeration of the spaces. In order to reduce the energy loss or gain through building envelop the thermal performance of window glazing is important (Grynning *et al*., 2013). Previous studies have also shown that among all the building architectural components window glasses are most responsible for heat gain in summer and heat loss in winter season in any building (Chaiyapinunt et al., 2005; Yin *et al*., 2012). Therefore, to reduce energy consumption the judicial selection and utilization of proper window glazing is most important.

Plate IV: view of shading element used.

Conclusion

The primary purpose of this study is to evaluate the adequacy of daylighting conditions in public libraries through the case study of selected libraries in Kaduna State Nigeria. It was observed that the conditions in the libraries studied have relatively poor daylighting design features necessitating the use of artificial lighting fixtures especially during the day. It was also noted that the use of electric light fixtures is only limited to particular hours of the day and under cloudy sky situations. These findings underscore the need for designers to consider daylighting factors when designing libraries and other forms of study areas in order to optimize their utility for users.

Reference

Aderemi, A. O., Ilori, M. O., Aderemi, H. O., & Akinbami, J. F. K. (2009). Assessment of electrical energy use efficiency in Nigeria food industry. *African Journal of Food Science*, *3*(8), 206-216.

Albatayneh, A., Alterman, D., Page, A., & Moghtaderi, B. (2018). The significance of the orientation on the overall building's thermal performance-case study in Australia. Energy procedia, 152, 372-377.

Aldawoud, A., & Clark, R. (2008). Comparative analysis of energy performance between courtyard and atrium in buildings. *Energy and Buildings*, 40(3), 209-214.

Boubekri, M., Cheung, I. N., Reid, K. J., Wang, C. H., & Zee, P. C. (2014). Impact of windows and daylight exposure on overall health and sleep quality of office workers: a case-control pilot study. *Journal of clinical sleep medicine*, *10*(6), 603-611.

Chaiyapinunt, S., Phueakphongsuriya, B., Mongkornsaksit, K., & Khomporn, N. (2005). Performance rating of glass windows and glass windows with films in aspect of thermal comfort and heat transmission. Energy and Buildings, 37(7), 725-738.

Daryanani, S. (1984). Design consideration for the daylighting of new commercial buildings. *Energy and Buildings*, *6*(2), 109–118. https://doi.org/10.1016/0378-7788(84)90065-3

Faisal, G., & Aldy, P. (2016, April). Typology of building shading elements on Jalan Sudirman corridor in Pekanbaru. In IOP *Conference Series: Materials Science and Engineering* (Vol. 128, No. 1, p. 012029). IOP Publishing.

Grynning, S., Gustavsen, A., Time, B., & Jelle, B. P. (2013). Windows in the buildings of tomorrow: Energy losers or energy gainers? *Energy and buildings*, 61, 185-192.

Morrissey, J., Moore, T., & Horne, R. E. (2011). Affordable passive solar design in a temperate climate: An experiment in residential building orientation. *Renewable Energy*, 36(2), 568-577.

Yildirim, K., Akalin-Baskaya, A., & Celebi, M. (2007). The effects of window proximity, partition height, and gender on perceptions of open-plan offices. *Journal of Environmental Psychology*, 27(2), 154-165.

Yin, R., Xu, P., & Shen, P. (2012). Case study: Energy savings from solar window film in two commercial buildings in Shanghai. Energy and Buildings, 45, 132-140.

SUB-THEME 4:
PLANNING FOR SUSTAINABLE RESILIENT NEIGHBOURHOODS AND CITIES IN COVID-19 ERA

GIS-Based Approach to Small Hydropower Potential Assessment Along River Ogun, Nigeria

Akande S.O.[1a], Sanusi Y.A.[1b], Sanni, L.M.[1c], Nda-Idris, A.[1d], & Santali, B.N.[1e]
[1]Department of Urban and Regional Planning, Federal University of Technology, Minna
[a]olaide.akande@futminna.edu.ng; [b]Yasanusi2@gmail.com; [c]sanni.lekan@futminna.edu.ng;
correspondence email: olaide.akande@futminna.edu.ng

Abstract

Electricity access is one of the challenges faced in Nigeria today; and this problem is more pronounced in the rural communities. Connecting rural communities to the national grid is always a problem due to the financial and logistical constraints of extending power through difficult terrain. To meet the energy demands of this deprived vast rural population, small hydropower plants are recommended to be built and installed. Small hydropower is a clean renewable and reliable energy alternative that meets the economic and environmental energy policy objectives. Improved technological development in GIS and remote sensing provides alternative methodologies for the assessment of theoretical hydropower potentials. This study provides a methodological pathway towards identifying small hydropower potentials for rural communities along the River Course. The primary data for the study include Digital Elevation Model (DEM), precipitation and evaporation collected in raster, and population data. The study identified a total of 57 potential hydropower sites with a maximum energy potential of 5.80 mw site in along Ogun River Channel in Ogun State. Ogun River has 75380kW of potential energy distributed along the river course in Ogun State. The estimated energy potential is expected to support about 22,040, 16530, and 11020 households at 100% 75% and 50% performance respectively. The study concludes that small hydropower plants are viable option for reducing the energy deficit of the country and can also help in the attainment of sustainable development goals 7 (universal energy access for all). The study recommends that government must take advantage of emerging GIS and remote sensing technologies to identify, estimate, and develop small hydropower plants for rural electrification while pursing and encouraging energy democratisation and decentralization.

Keywords: Electricity, Small hydropower potential, GIS, and Rural Electrification.

1.0 Introduction

Electricity is one of the most important drivers of development in the world, particularly in the 19th century and beyond. However, according to International Energy Agency (IEA), 2022, about 770 million people live without access to electricity in the world today; mostly in Africa and Asia. Significant progress was recorded in access to electricity in the world between 2013-2019, but for the global pandemic (COVID-19), the number of people without access increased in 2020 for the first time since 2013. Hence, increasing the concerns of electricity access in the world and Africa in particular through sustainable means.

Hydropower is undoubtedly one of the most sustainable, reliable, clean, and renewable energy sources that serves both energy and national environmental policy objectives (Kusre *et al.*, 2009). It is a major renewable energy source for electricity production due to its reliability and it produces less greenhouse gas emission. Hydropower energy system comes with numerous advantages among which are low operation and maintenance cost, less greenhouse gas emission, high efficiency (above 60%), and longer life span (Hatata *et al.*, 2019).

Small hydropower (SHP) is one of the numerous off-grid alternatives to electric grid extension that provides communities outside the grid network with electricity and usually serve as supplement in urban areas or large cities (Eshra *et al.*, 2021). No universally acceptable definition of small hydropower exists, however, the smallness of hydropower ranges from 1-10MW in literature (Khare *et al.*, 2019; Morales *et al.*, 2014; Paish, 2002). According to Ghorbani *et al.* (2020) small hydropower is one of the most popular renewable energy sources with very little or no environmental and social implication compared to large scale hydropower system (Yadoo and Cruickshank, 2012). Despite the numerous advantages of small hydropower and abundant water resources in Nigeria; SHP potential remains relatively untapped (Adedeji, 2016).

Nigeria has abundant hydropower potentials, yet has failed to utilise these resources maximally. About 12.4% of Nigeria's landmass is covered with water (Ita *et al.*, 1985), yet only about 20% (IEA, 2014) of Nigeria's electricity generation comes from hydropower, which are mostly large hydropower plants (e.g., Kainji, Shiroro, and Jebba). In the face of abundant water resources, Nigeria, is facing serious crisis in electricity generation and this has serious implication on the level of electricity access in the country. According to the International Energy Agency (2016), electricity access in Nigeria stands at 55% in urban areas and 36% in rural areas, while about 134 million people (76 percent) rely on traditional fuelwood for energy. The increasing use of fuelwood as energy alternative increases the temperature of the environment leading to greenhouse effect thereby increasing climate change concerns.

Access to sustainable electricity is critical to the achievement of SDGs goal 7 (affordable and clean energy) and goal 13 (Climate Action) as well as the development of many sectors of a nation including education, water, industrialization, and health. Hence, achieving most of the SDGs, particularly goals 7 requires concerted efforts towards the generation and distribution of electricity to all citizens in the rural and urban areas of the country. Small hydropower according to Paish (2002), are now the greatest alternative, providing a considerable, long-lasting, and cost-effective source of energy with minimal environmental impact.

In other to ensure energy access for all by year 2030, rigorous attempt towards energy decentralisation and adoption of programmes that promotes energy mix (on-grid and off grid energy solution) must be pursued (PPEO, 2017). The urban-rural dichotomy must be balanced and this can be achieved through the use of off grid energy solutions, particularly small hydropower. According to Energy Commission of Nigeria (ECN, 2004), only twelve of the thirty-six states of the country has been surveyed for SHP; these states have a total SHP potential of 734.2MW identified over 277 SHP potential sites. However only about 5% of the SHP potential has been harnessed in only four states in the country (ECN, 2004). The recent advancement in technology and geographic information system (GIS) has provided a cost effective and fast approach to small hydropower survey and assessment using remote sensing data. This study is therefore an attempt to showcase a pathway towards effective survey and viability assessment of small hydropower potentials for electricity generation along Ogun River using GIS and remote sensing technology.

2.0 Study Area

One of the most prominent rivers in Ogun State among which are River Oyan, Oshun, and Oni. The river runs from Osun state in the north to the south in Lagos state before emptying into the Atlantic Ocean. However, the focus of this study will be on the stretch of the river within Ogun State (Figure 1). River Ogun within Ogun State traverses five local government areas (LGAs) of the state; Abeokuta north, which is partly urban and partly rural, Abeokuta south (100% urban), Ifo, Obafemi-Owode and Odeda. River Ogun is a permanent river and its mostly recharged through rainfall. Ogun State experienced at least 9 months of rainy season from March to November and intermittent rain for the rest of the year (Azodo, 2014). It is also instructive to know that Ogun State is the home to many industries in Nigeria and hence there is high competition for residential and industrial energy use. The seemingly inadequate energy access for urban residential and industrial use is likely accountable for the low or no level of energy access experienced in many rural communities in the State.

3.0 Methodology

3.1 Data Types and Sources

1. Shuttle Radar Topographical Mission of 0.00083 by 0.00083 degrees resolution was downloaded form United States Geological Survey (www.usgs.com) (DEM)

2. Shapefiles of communities within 2km radius of River Ogun was downloaded from OpenStreetMap (www.openstreetmap.com)

3. The energy access level of the communities was determined through survey

4. Per capita annual consumption in Ogun State in 2016 and 2017 was sourced from Ibadan electricity Distribution company (IBEDC)

5. Monthly precipitation and evaporation dataset was downloaded from Dieulin *et al*. (2017)

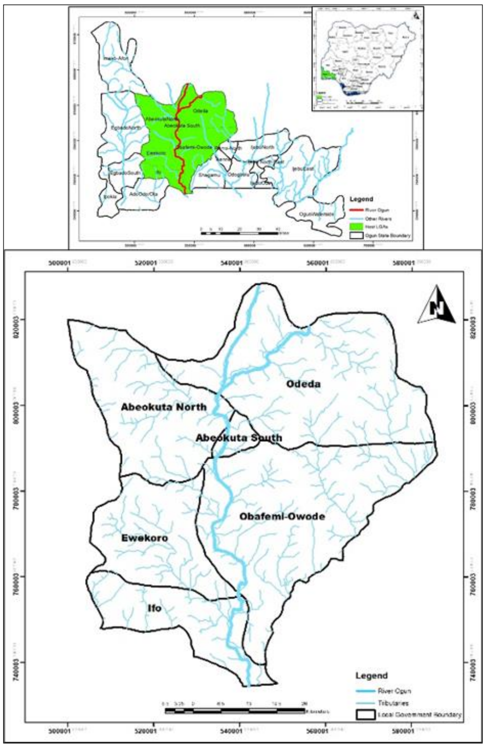


Figure 1: River Ogun and Tributaries in the Context of Ogun State

3.2 Procedure for Spatial Analysis of SHP Potential Sites

The procedure for small hydropower potential sites identified in this study is depicted in Figure 2. The steps involved in the procedure is presented in the following order

1. A DEM of 0.00083 by 0.00083 degrees resolution was loaded into ARCGIS 10.8 environment
2. The DEM was masked with a 2km buffer vector shapefile of River Ogun
3. The resulting DEM of the area was filled for void to derive a resulting DEM without sink
4. The result of step three (DEM without sink) was used to estimate the flow direction of the area which is called FD
5. The direct runoff data set was resampled according to the masked DEM using the resample function in ARCGIS
6. The resampled data was converted to integer to aid processing
7. The output of the flow direction (FD) and the direct runoff dataset (integer) were loaded as input data for the calculation of flow accumulation and the resulting raster was labelled "m"
8. Focal statistics analysis function was carried out on the masked DEM of the study area to derive a DEM labelled Minimum neighbours (MN)
9. The minimum neighbours (MN) were deducted from the initial Masked DEM of the area to derive the head "h" which is the difference in height of neighbouring cell
10. The amount of runoff per raster (flow rate) labelled "m" was multiplied by the head (difference in height) to arrive at a raster called "mh"

11. The result of step 10 labelled "mh" was multiplied by the value of gravity labelled "g" to derive to energy potential of the cells in kilojoules.
12. The output in kilojoules was transformed to kWh and MW h by using the calculation factor ($1/3.6 * 10^{12}$)

3.3 Method of Data Analysis

Spatial analysis and descriptive analysis were the analytical tools used for data analysis. The spatial analysis tools used include fill, flow direction, flow accumulation, resample, buffer analysis, focal statistics, and map algebra function in ARCGIS 10.8 environment. The spatial analytical techniques were used to identify small hydropower potential sites at various stages of the analysis. In addition, simple descriptive analytical tools such as frequency, minimum, maximum, and mean were also computed for easy understanding of the data. To estimate the energy potential of the potential sites in joules, the advanced energy equation advanced by Carroll *et al.* (2004) which is mathematically expressed in equation (1) was adopted.

$$E = m * g * h \tag{1}$$

Where E= "gravitational potential energy, measured in Joule J", m = mass (amount of runoff per raster); g = gravitational force (9.8); h= height (head/slope)

Note: The output dimension is in Joules which then has to be transformed to kWh and MW h by using the calculation factor ($1/3.6 * 10^{12}$)

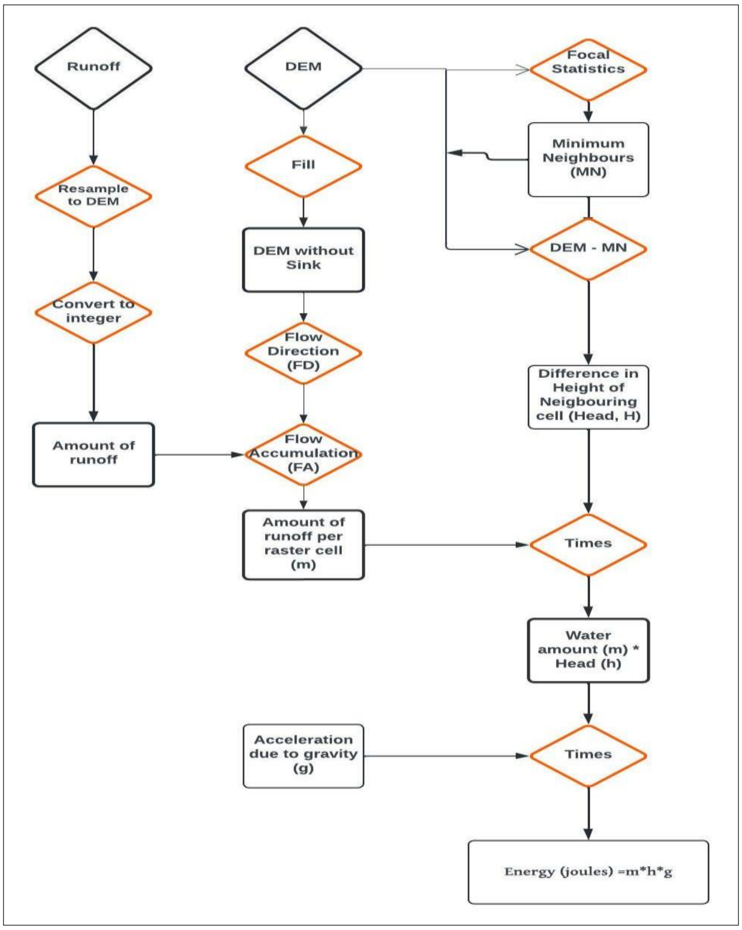


Figure 2: Flow Chart of the Research Methodology

Source: Adapted from Feizizadeh & Haslauer (2012)

3.4 Minimum Electricity Threshold Required to Meet SDG 7

Energy reliability, affordability, and sustainability are the key goals of Sustainable Development Goal 7. However, it does not set the minimum per capita energy threshold to be achieved to ensure energy access for both residential and non-residential sector. Hence, there is no universally acceptable electricity consumption threshold; electricity access threshold varies across countries and continents of the world. For example, Moss *et al.* (2020) proposed a minimum energy benchmark of 1000kwh per capita per annum inclusive of residential (300 kWh) and non-residential (700 kwh) electricity consumption for the achievement of SDG 7. IEA (2015) also proposed a minimum threshold of 250 and 500 kWh/year for rural and urban households (assumed to be five persons) respectively. Similarly, Brecha (2019) also argued that a minimum electricity threshold of at least 400kwh is closely to meeting the outcomes of SDG 7. Based on the economic dynamics and rural nature of most communities within two-kilometre radius of the identified SHP potential sites in Ogun State, IEA (2015) minimum threshold value of 250kWh per household (5 persons) will be adopted as the minimum energy threshold for energy analysis in this study.

4.0 RESULTS AND DISCUSSION

4.1 Characteristics of River Ogun

River Ogun stretches for 118.1km from north to south within Ogun State boundary and it is the longest and biggest river in the State (Table 2). The minimum elevation along the river path is 1.003m and a maximum 103.9m above sea level. The vertical difference between the start point of the river in the north and the finish point is about 102.9m. This significant difference in vertical height along the river channel will provide good head (gradient) required for the development of hydropower plant. The maximum slope along the river channel is 7.02^{O} which is also good for small hydropower development. The North-South profile of River Ogun is depicted in Figure 3. The Figure shows the undulating nature of the river channel and the flow direction of water from the north at (7° 24' 12.9605" N, 3° 30' 29.6205" E) to south (6° 38' 39.0696" N, 3° 22' 51.5256" E).

Table 2: Physical Characteristics of River Ogun

Characteristics	Value
Start Position:	7° 24' 12.9605" N, 3° 30' 29.6205" E
End Position:	6° 38' 39.0696" N, 3° 22' 51.5256" E
Minimum Elevation on Path:	1.003 m
Maximum Elevation on Path:	103.897 m
Vertical Difference (Start to Finish):	102.9 m
Path Length:	118.1 km
Straight-Line Distance:	85.153 km
Minimum Slope/Tilt:	-0.05°
Max Path Slope:	7.02° [104.13 km along path]
Flow direction	North to South

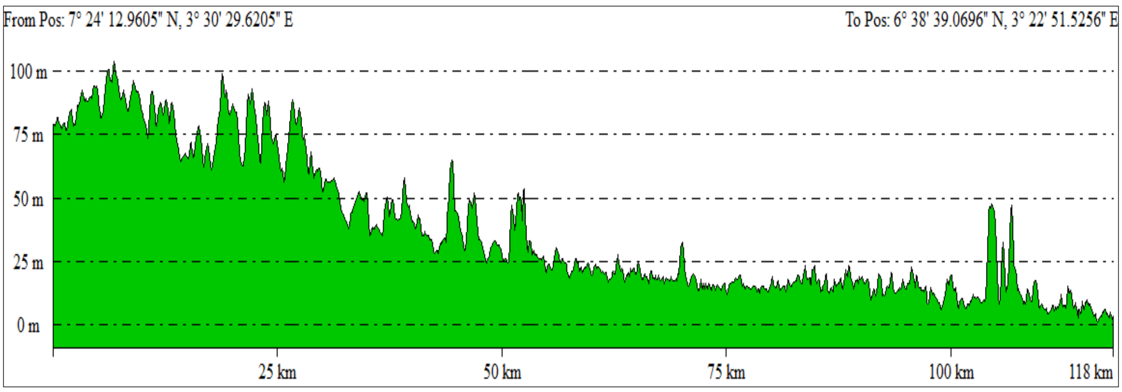


Figure 3: Profile A-A Showing the Section of River Ogun from the North to South

4.2 Quantity of Discharge and Slope along River Ogun

The quantity of discharge (flow rate) and the difference in vertical difference in elevation called "head" or "gradient" are the primary factors for energy potential estimation in run off river. The higher the vertical difference in elevation and quantity of discharge, the higher the potential energy generated. Table 3 shows the characteristics of discharge and head along River Ogun. The result shows that a minimum slope of 0.3 metre at Ifo LGA and a maximum slope of 24.3 metre was identified along the river at Abeokuta South LGA. The average annual discharge ranges from 82.8m^3 in Odeda to 183.4m^3 in Ifo.

Table 3: Slope and Quantity of Discharge along River Ogun

River	Min head	Max head	Min Monthly Q/Discharge (m^3)	Max Monthly Q/Discharge (m^3)	Annual Mean Q/Discharge m^3
Odeda	0.7	18.2	4.1	368	82.8
Abeokuta North	0.9	14.1	4.94	612	132.5
Abeokuta South	0.4	24.3	9.77	617	168.8
Obafemi-Owode	0.4	13.1	10.5	635	172.5
Ifo	0.3	16.2	11.7	658	183.4

The quantity of discharge increases as the river flows towards the south in Ifo LGA. The analysis revealed that there is a wide variability in head and discharge distribution along the river course. Hence, the river can support the generation of varying level of electricity.

4.3 Distribution of Small Hydropower Potential Sites Along River Ogun

The study identified a total of 57 small potential hydropower (SHP) sites along River Ogun (Table 4). The small hydropower potential sites were distributed across five local government areas of Ogun State. Majority of the potential sites (21) were identified along the river channel in Odeda local government area (LGA) which is one of the adjoining LGA to the State Capital Abeokuta. Obafemi Owode LGA had 11 SHP sites and Ifo had 10 SHP sites along River Ogun. Abeokuta North and Abeokuta South had 6 and 9 SHP sites respectively; these two LGAs are the home to the State capital Abeokuta.

The energy potential available in the 57 potentials were also classified into three; namely 0.500-1.000mw, 1.001-3.000mw, and above 3.000mw. Table 4 shows that at least 15 potential sites can support 0.5000-1.001mw of electricity, 34 sites can support 1.001-3.000mw, while only 8 sites can support above 3.000mw of electricity.

Table 4: Characteristics of Stream Network in Ogun Watershed

LGAs	0.500-1.000 MW	1.001-3.000 MW	3.001-5.798 MW	No Hydropower Site
Abeokuta North	0	5	1	6 (10.5%)
Abeokuta South	4	5	0	9 (16%)
Ifo	2	7	1	10 (17.5%)
Obafemi-Owode	0	8	3	11 (19%)
Odeda	9	9	3	21 (37%)
Total	**15 (26%)**	**34 (60%)**	**8 (14%)**	**57 (100%)**

The distribution of the potential sites across five LGAs in Ogun state shows that communities from different LGAs are likely to benefit from the SHP sites when developed. It can also serve as a tool to stimulate development across different LGAs of the state. The distribution pattern of the SHP potential sites is presented in Figure 4.

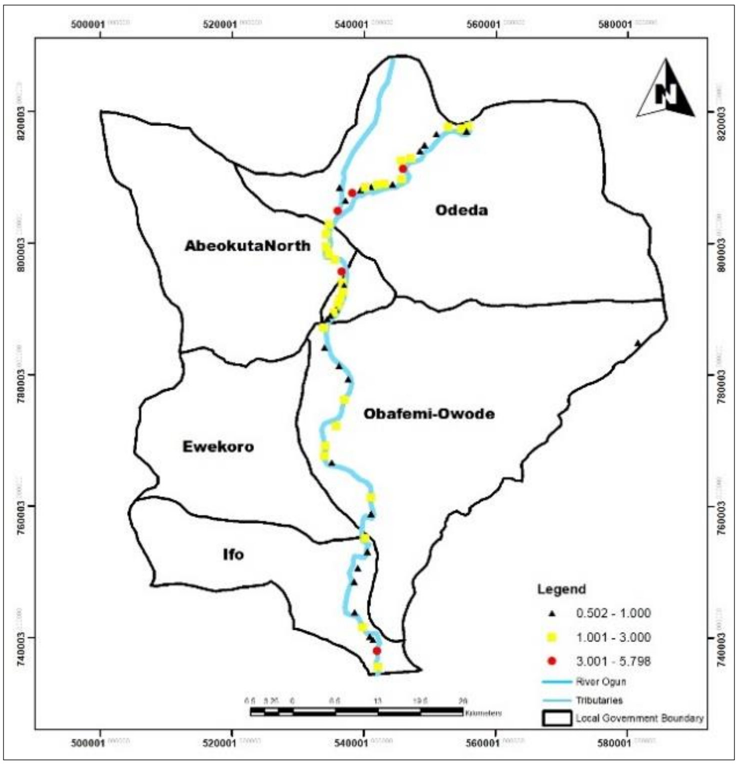


Figure 4: Categories of SHP Potential Sites along River Ogun

4.4 Estimated Small Hydropower Potentials Identified Along River Ogun

The estimated electricity potentials estimated per sites along River Ogun ranges from 0.502mw in Ifo LGA to 5.798mw in Abeokuta North LGA (Table 5). The variability in the energy potential estimated across the sites is a function of the available head and the rate of flow at the discharge point. Table 5 shows that a total of 13.48mw of electricity potential can be generated from six potentials sites along the river in Abeokuta North, 9.94mw from nine (9) potential sites in Abeokuta South which is 100% urban and doubles as the state capital. The maximum electricity potential of 30.05mw was estimated along the river in Odeda LGA from twenty-one (21) potential sites. A total of 75.38mw what of energy was estimated from a total of 57 sites along the river course and across five LGAs.

Table 5: Estimated Energy Potentials of the Identified SHP Sites

River	Min Pwr (mw)	Max Pwr (mw)	Total SHP Potential (mw)
Abeokuta North	1.106	5.798	13.48
Abeokuta South	0.510	2.096	9.94
Ifo	0.502	3.133	10.53
Obafemi-Owode	0.535	1.906	11.38
Odeda	0.513	3.284	30.05
Total			**75.38**

4.4 Energy Access Situation of Communities along River Ogun

The study examined the energy access situation of communities located along two kilometres radius of River Ogun in other to assess the viability of potential SHP sites. The study identified a total of fifty-seven rural communities and one urban centre (Abeokuta) the state capital of Ogun State (Table 6). The result shows there are at least 25 rural communities (hamlet/village) along 2 kilometres radius of River Ogun, 16 in Obafemi-Owode, 13 in Ifo, 3 in Abeokuta North and one town (Abeokuta) in Abeokuta South LGA. Interestingly, none of the rural communities located along the river within 2 kilometres distance are connected to the national grid or any off-grid electricity system, and hence had no access to public energy supply. Abeokuta on the other hand is connected to the national grid. The vast population of communities along the river course without access to electricity provides the requisite demand for the potential energy within reasonable distance. The distribution of the communities along the river course is depicted in Figure 5.

Table 6: Energy Situation of Communities along River Ogun

River	Communities	Development Status	Energy Access Status
Abeokuta North	3 (5%)	Rural	Not Connected
Abeokuta South	1 (2%)	Urban	Connected
Ifo	13 (22%)	Rural	Not Connected
Obafemi-Owode	16 (28%)	Rural	Not Connected
Odeda	25 (43%)	Rural	Not Connected
Total	**58 (100%)**		

4.5 Projected Household Population to be Serviced with Electricity

The study provides an insight into the possible number of households (average of five members) that can be provided with a minimum energy threshold of 250kWh per annum. This is equivalent to an average daily electricity access of 0.68kWh per capita and 3.4kWh per household per day. Based on this standard, the number of households to be served was estimated at 100%, 75% and 50% performance of the potentials identified. The result shows that at maximum performance capacity of 100% for a household of five, 22,040 households can be powered with electricity, 16531 households at 75% performance and 11020 households at 50% performance of the SHP potentials. This shows that a minimum of 11020 households can be lifted out of energy poverty with a minimum access to 250Kwh per annum per household. This can also serve as an inclusive approach towards connecting communities (mostly rural) far away from national grid due to topographical or logistical constraints into public energy system through off-grid system using SHP.

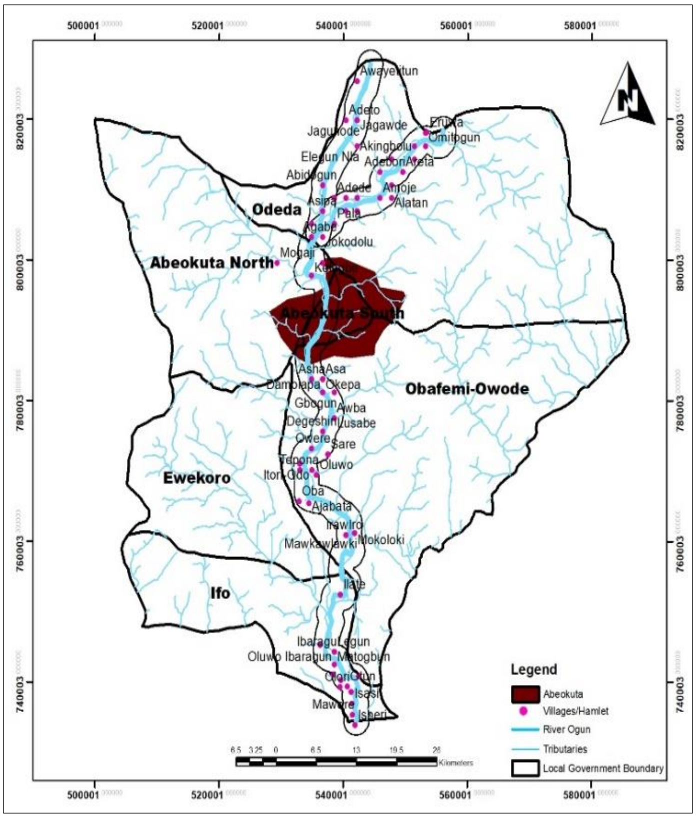


Figure 5: Communities within two kilometres Radius of River Ogun

Table 7: Projected Household Population to be Serviced with Electricity

River	Energy Potential (kWh)	No of Households to be served 100%	75%	50%
Abeokuta North	13480	3942	2956	1971
Abeokuta South	9940	2906	2180	1453
Ifo	10530	3079	2309	1539
Obafemi-Owode	11380	3327	2496	1664
Odeda	30050	8786	6590	4393
Total	**75380**	**22040**	**16530**	**11020**

5.1 Conclusion

The results have shown that GIS and remote sensing data can provide the requisite technology needed to identify potential sites in a cost-effective manner and within a reasonable period of time. This is a much better approach to the traditional water resources assessment approach using discharged data at outlet of watershed. Therefore, spatial identification and quantification of small-scale hydropower potential is expected to be an important addition to the field of spatial electrification planning. The available small hydropower potentials estimated are enough to stimulate efforts towards identifying small hydropower potentials in the country with a view to harnessing same for electrification, particularly in rural areas off the national grid. These will ensure equitable provision of electricity all irrespective of location and level of development. Small hydropower has become more important than ever in many countries of the world including China, Germany, Spain, and India among others particularly with its attendant low carbon footprint.

It is also evident that small hydropower can be used to reduce the level of energy poverty for a minimum of 11020 households as well as reducing the carbon footprint of the communities. Harnessing the small hydropower potential across the country provides a huge prospect for the attainment of SDGs 7 and 13 and facilitate the achievement in education, health, and production, thereby leading to increase wellbeing of the population and higher gross domestic product for the country. This study therefore concludes that achieving inclusive energy access in Ogun State and the country at large requires the promotion of energy mix through on-grid and off-grid approach of which small hydropower is one. Hence, energy democratisation and decentralisation must be pursued vigorously to provide the requisite environment for the promotion of off-grid energy systems, particularly SHP.

5.2 Recommendations

The following recommendations were evolved from the findings of the study;

1. The government must also take advantage of the technological advancement, particularly in GIS and remote sensing for small hydropower assessment in order to facilitate the identification and estimation of small hydropower potentials in a cost effective and sustainable manner.
2. The government must also provide policies that will drive the decentralization of electricity generation in the country through diverse sustainable pathways.
3. Areas of requisite electricity potential in the country should be mapped and advertised to encourage investment in that direction.

References

Adedeji, A. A. (2016). *Spatial Exploration and Analysis of Electricity Poverty: A Case Study of Ibadan, Southwestern, Nigeria*. University of Leicester.

Azodo, A. P. (2014). Electric power supply, main source and backing: A survey of residential utilization features. *International Journal of Research Studies in Management*, *3*(2), 87-102.

Brecha, R. (2019). Electricity access threshold for meeting non-energy SDG targets. *European Journal of Sustainable Development*, *8*(4), 90-90.

Dieulin, C., Mahe, G., & Paturel, J-E., Soundouss, E., & Rouché, N., & El-Mansouri, B. (2017). Monthly rainfall gridded dataset for Africa for the period 1990-1999 at the half a square degree, interpolation Inverse Distance Weighted.

Energy Commission of Nigeria (ECN) (2004). Guide book on Small Hydro power Development in Nigeria; Planning, Policy and Financing issues

Eshra, N. M., Zobaa, A. F., & Aleem, S. H. A. (2021). Assessment of mini and micro hydropower potential in Egypt: Multi-criteria analysis. *Energy Reports*, *7*, 81-94.

Feizizadeh, B., & Haslauer, E. M. (2012). GIS-based procedures of hydropower potential for Tabriz basin, Iran. International Journal, 495-502.

Ghorbani, M. A., Deo, R. C., Kim, S., Hasanpour Kashani, M., Karimi, V., & Izadkhah, M. (2020). Development and evaluation of the cascade correlation neural network and the random forest models for river stage and river flow prediction in Australia. *Soft Computing*, *24*(16), 12079-12090.

Goyal, M. K., Singh, V., & Meena, A. H. (2015). Geospatial and hydrological modeling to assess hydropower potential zones and site location over rainfall dependent Inland catchment. *Water Resources Management*, *29*(8), 2875-2894.

Hatata, A. Y., El-Saadawi, M. M., & Saad, S. (2019). A feasibility study of small hydro power for selected locations in Egypt. *Energy Strategy Reviews*, *24*, 300-313.

Ibadan Electricity Distribution Company (IBEDC), (2017). Ibadan Electricity Distribution Company Annual report. Ibadan: IBEDC

IEA (2022), SDG7: Data and Projections, IEA, Paris https://www.iea.org/reports/sdg7-data-and-projections, License: CC BY 4.0.

International Energy Agency (IEA). (2016). World Energy Outlook 2016: Executive Summary. *World Energy Outlook*, 1–8.

International Energy Agency (IEA). (2015). World Energy Outlook 2015: Methodology for Energy Access Analysis, 8. https://doi.org/10.1787/weo-2014-en.

International Energy Agency (IEA) (2014). *The World Energy Outlook 2014: Outlook for African Energy to 2040.* International Energy Agency: Paris, France.

Ita, E. O., Sado, E. K., Balogun, J. K., Pandogari, A., & Ibitoye, B. (1985). Inventory survey of Nigeria inland waters and their fishery resources. Part 1. A preliminary checklist of inland water bodies in Nigeria with special reference to ponds, lakes, reservoirs and major rivers.

Khare, V., Khare, C., Nema, S., & Baredar, P. (2019). Introduction to energy sources. *Tidal energy systems. Elsevier, Amsterdam*, 1-39.

Kusre BC, Baruah DC, Bordoloi PK, Patra SC. (2010). Assessment of hydropower potential using GIS and hydrological modeling technique in Kopili River basin in Assam (India). *Applied Energy* 87: 298–309. DOI: 10.1016/j.apenergy.2009.07.019

Memarian, H., Balasundram, S. K., Abbaspour, K. C., Talib, J. B., Boon Sung, C. T., & Sood, A. M. (2014). SWAT-based hydrological modelling of tropical land-use scenarios. *Hydrological sciences journal*, *59*(10), 1808-1829.

Morales, S., Corredor, L., Paba, J., & Pacheco, L. (2014). Stages in the development of a small hydropower project: Context and implementation basic criteria. *Dyna*, *81*(184), 178-185.

Moss, T., Bazilian, M., Blimpo, M., Culver, L., Kincer, J., Mahadavan, M., ... & Webber, M. (2020). The Modern Energy Minimum: The case for a new global electricity consumption threshold. *Energy for Growth Hub*.

Omani, N., Srinivasan, R., Karthikeyan, R., & Smith, P. K. (2017). Hydrological modeling of highly glacierized basins (Andes, Alps, and Central Asia). *Water*, *9*(2), 111.

Paish, O. (2002). Small hydro power: technology and current status. *Renewable and sustainable energy reviews*, *6*(6), 537-556.

Pandey, A., Lalrempuia, D., & Jain, S. K. (2015). Assessment of hydropower potential using spatial technology and SWAT modelling in the Mat River, southern Mizoram, India. *Hydrological Sciences Journal*, *60*(10), 1651-1665.

Poor People's Energy Outlook (PPEO) (2017). *Financing National Energy Access: A Bottom Up Approach*. Practical Action Publishing: Rugby, Warwickshire, United Kingdom

Sammartano, V., Liuzzo, L., & Freni, G. (2019). Identification of potential locations for run-of-river hydropower plants using a GIS-based procedure. *Energies*, *12*(18), 3446.

Stehr, A., Debels, P., Romero, F., & Alcayaga, H. (2008). Hydrological modelling with SWAT under conditions of limited data availability: evaluation of results from a Chilean case study. *Hydrological sciences journal*, *53*(3), 588-601.

Yadoo, A., & Cruickshank, H. (2012). The role for low carbon electrification technologies in poverty reduction and climate change strategies: A focus on renewable energy mini-grids with case studies in Nepal, Peru and Kenya. *Energy Policy, 42,* 591-602.

Analysis of Women Benefits from Participation in Social Networks in Gulu Vatsa Area of Niger State

Martins, V.[1a] * & Tsado, E.[1b]
[1]Department of Urban and Regional Planning, Federal University of Technology Minna
[a]Valda.Martins@futminna.edu.ng; [b]emmanueltsado@gmail.com
Corresponding author: Valda.Martins@futminna.edu.ng

Abstract

The past three decades has seen a change in the ever-increasing rate of women dependence on just family for benefits to dependence on relationships and social networks built within the immediate environment and the society at large. A growing body of literature have shown how Social Networks have progressively become an important vehicle of social, economic and political empowerment as it regards women livelihood activities. Through qualitative interviews this study investigates the intangible and tangible benefits the women of Gulu Vatsa area gain from engagements in social network activities. Having projected the 1991 ward population data of Gulu Vatsa women to 2020 the population figure of 13,627 was arrived at. Purposive sampling technique was adopted to administer the questionnaire within the ward to the 54 women who were the selected sample size. The study reveals financial benefits was the standout benefits among the different gains acquired by the women of Gulu Vatsa ward through social networks, with the networks giving easy access to short term loans and also opening up larger market for the women livelihood activities, it was also discovered that tangible benefits like sewing and grinding machines are also benefits from their social networks. The results from this study makes a very strong case for putting in place appropriate polices that would support and promote the participation of women in social network activities which would improve their livelihood activities.

Keyword: Social Network, Women Participation, Livelihood Activities.

Introduction

The participation of women in certain social activities is reliant on them being adequately clothed, well nourished, having shelter and generally having the capacity to avoid preventable morbidity that have to do with lacking financial resources and socio relations. Poverty as defined by Martins (2019) is deprivation, being completely reliant on people and having no form of absolute decision-making capacity. According to Martins, it is not just the lack of housing, nutrition, clothes, and other important needs of life, but also lack of social capital. All over the world today, Women suffer from different practices, which leads to them suffering inequalities and biased practices. Despite the fact that studies have proven that the women entrepreneurs in developing countries are better in finance utilization within the different sectors of the society's economy.

According to Arora & Meenu (2010) women are considered to be at the lowest rung of the poverty ladder, this Okpukpara, (2009) attributed to social exclusion, lack of access to resources, education and capacity building activities. This situation has resulted to the women in Lapai Local Government especially Gulu Vatsa area to be reliant on social networks activities as they have discovered the possible benefits, they stand to accrue from participation in social network with it giving access to financial resources and social inclusion which cover-up for the social bias and inequalities of different form they often encounter. This paper therefore, analyse the benefits women acquire from engaging in social network activities within Gulu Vatsa area of Lapai Local Government area of Niger state.

Concept of Social Network

Over the past 20 years, social networks have played important roles in simplifying human activities (Faist and Ozveren 2004). Networks have been seen progressively as important means of understanding and carrying out the different human activities in the world (Castles and Miller, 2003). The manner of building these networks according to Boyd (1989), are subjective to certain variant factors, the relationships that arise as a result of the networks influence the livelihood decisions of individuals at particular times. Thus, social networks are key element in facilitating livelihood activities. Social networks are however, often conceptualized rather loosely, with little attention given to the multiplicities in networks and the different forms of support they may provide.

Social networks are regarded as important sources of social capital for human livelihood activities as it gives access to social support, with social capital and networks frequently seen as synonymous hence the suggestion that social capital as a concept is rooted in social networks and social relations and must be measured relative to its root. Putnam Robert (2007) offered what he termed 'a lean and mean 'definition of social capital as social network and the associated norms of reciprocity and trustworthiness. The central premise of social capital is that individuals benefit from various norms and values that a social network foster and produces such as trust, reciprocity information and cooperation. These norms and value provide the preconditions for collective actions.

Concept of Livelihood

Livelihood according to Shyamalie and Saini (2010) involve the flow of monetary and non-monetary resources that are exploited for continuous sustenance. Schraven *et al* (2016), define livelihood as a multifaceted system consisting of assets, which can be material or social possessions and other activities through which a means of living is generated. Schraven et al (2016) went further to imply that the material assets could be those which are tangible and through which a person or people can generate a living. Livelihood in the opinion of Datta *et al* (2010) involve the command of social and cultural means an individual, family or social groups have over income or bundles of resources that can be used or exchanged to satisfy their needs. It involves culture, information, knowledge, social networks and legal rights as well as land, tools and other physical resources.

According to Isaac *et al* (2019b) livelihoods of women are affected by social, economic, religious and political contexts surrounding them. The institutional frameworks within a community influence the livelihoods of women according to United Nations Development Programme (2010). Rahman and Akkter (2012) stated that livelihood analysis is a complex exercise owing to its multidimensional nature.

Concept of Livelihood Assets

Livelihood assets refer to the resource base of the community and of different individual households. Scoones (2009) noted that tangible and intangible assets that people use for constructing their livelihoods are conceptualized in forms of capital to emphasis the role they play as part of the productive streams from which livelihoods are constructed. Vincent and Cull (2010) maintained that, the higher the assets owned, available and controlled by an individual or community the lesser the vulnerability level of such individual. The lower the assets available controlled and owned by an individual or community the higher the vulnerability level of such individual.

UNDP (2010) noted that the livelihood strategies of individuals, households and communities are determined by the availability of assets in terms of access, ownership and control. These Livelihoods assets are those natural or artificial materials available to man through which he makes a living. Morse and McNamara (2013) provided an analytical framework to aid understanding of the five dominant form of livelihood assets that influence people's ability to achieve sustainable livelihoods, these dominant forms of livelihood assets are (natural, physical, human, financial and social assets) which are the major complementary building blocks for livelihoods sustainability.

i. **Natural Capital:**

The natural resource base from which resources useful for livelihoods activities are derived. Natural capital includes all naturally occurring factors that can be the fulcrum for livelihood activities. Natural capital has two dimensions, namely natural resources and ecological services. The natural resources include soil, water, sun, forests and rainfall; while the ecological services include the hydrological cycle and atmospheric sink (Morse and McNamara, 2013). Although natural capital may be available to everyone, access to certain natural capitals may be restricted based on gender and other socio-economic features.

ii. **Physical Capital:**

This form of capital has to do with tools and equipment's as well as infrastructure and services available to an individual, household or community. Physical capital is important not only for meeting peoples need directly but also for providing access to other capitals. Approaching the issue of physical capital from the gendered perspective, UNDP in (2010) contended that women are deprived of equal access to, ownership of and control over livelihood assets as the men, this according to them is due to culturally biased institutions, policies and norms that tend to stimulate gender-based deprivation in the aspect of physical capital.

iii. **Financial Capital:**

The financial resources which are available to people which provide them with different livelihood options (Rutendo 2017). It is often by definition the most limiting asset of poor people, but it is one of the most important, in that it can be used to purchase other types of capital, and can also be used to influence other people. Financial capital provides opportunities for engagement in specific livelihood options for a considerable choice of time.

iv. **Human Capital:**

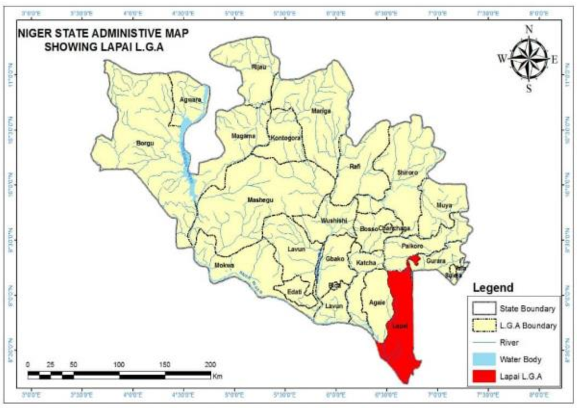
The skills, knowledge and good health are important to the ability to pursue livelihood strategies. Human capital has both qualitative and quantitative dimensions (Isaac *et al*., 2019). The qualitative dimensions of human capital include level of education, type of skill, professionalism and health status. The quantitative dimension on the other hand includes household size and number of hours worked per day.

v. **Social Capital:**

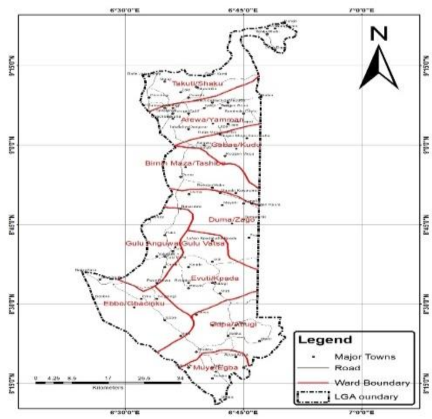
The horizontal and vertical social resources (networks, membership of groups, relationships of trust, access to wider institutions of society) upon which people base their pursuit of livelihood. Vincent and Cull (2010), argued that livelihood vulnerability can also be influenced through availability and access to social capital, they stated that social capital is of essential value, as it increases well-being, facilitates the generation of other capital and provides services to generation of the framework of the society in general, with its cultural, religious, political and norms of behavior. Kyeremeh (2014) stated that lack of social capital and social exclusion, can be highlighted as a significant characteristic of poverty.

Study Area

Lapai is a Local Government Area in Niger state located along the south-eastern part of the state, it shares boarder with Paikoro and Agaie Local Government area. The Local Government has land coverage of 3,051 km² and a total population figure of 110,127 according to 2006 census (Niger State Bureau of Statistics 2012). The Local Government is located on longitude 9°03′00″N and latitude 6°34′00″E near the Gurara River, which is a tributary to the Niger River. The study is one out of the ten (10) wards located within Lapai Local Government Area.



a



b

Figure 1: Maps Showing Study Location

Methodology

The data required for the purpose of this survey include socioeconomic data, demographic data, data on choice of social networks, and data on perceived benefits from participation in social network activities. The required data information was collected from the women in Gulu Vatsa Area through observation and questionnaire administration. The projected population of women of Gulu Vatsa area from the 1991 population to 2020 population figure of 13,627, with Morgan and Kreji sampling calculator establishing the sample size to be 54. This survey adopted a non-probability sampling technique, reason being that the targeted population is not well defined.

Results and Discussion

Factors Influencing Participation in Social Network

The participation of women in social network activities from the survey carried out, highlighted the major factors that influence women involvement in social network groups in Gulu Vatsa area of Lapai Local Government as analysed using Linkert scale. The survey reveals that 55% of the women strongly agreed that financial benefit is the factor that influences their participation in social network activities with these networks giving them access to different forms of loans as well as providing a larger market for their businesses. However, 2.71% strongly disagree that financial benefits is the reason for participating in social network activities. 27% on the other hand agreed that Business growth is the factor that inspires their engagement in social network group activities with 4% disagreeing that business growth is the reason behind their participation in social network activities. it was established from 32% of the women that strongly disagreed that Recognition is not a pulsating factor that influence women engagement in social networks activity within Gulu Area of Lapai local government.

Table 1 Factors that Influences women participation in Social Networks

	Strongly Agree		**Agree**		**Neutral**		**Disagree**		**Strongly Disagree**	
Factors	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Financial Benefit	206	55.83	117	31.71	26	7.05	15	4.07	5	1.36
Business Growth	194	52.57	102	27.64	41	11.11	22	5.96	10	2.71
Social Security	121	32.79	150	40.65	35	9.49	12	3.25	51	13.82
Asset Acquisition	111	30.08	143	38.75	36	9.76	42	11.38	37	10.03
Employment Opportunity	123	33.33	105	28.46	53	14.36	18	4.88	70	18.97
Environmental Security	96	26.02	103	27.91	81	21.95	46	12.47	43	11.65
Social Ties	61	16.53	83	22.49	112	30.35	76	20.60	63	17.07
Recognition	13	3.52	26	7.05	98	26.56	112	30.35	120	32.52

Ranking Factors That Influence Participation in Social Network Activities

As revealed by Table 2 Financial benefit ranked highest among the selected factors that influence women participation in social networks activities with a mean of 4.37.

Table 2 Ranking of the Factors that Influences Social Network Participation (Note: Strongly Disagree (1:1.80), Disagree (1.80: 2.60) Neutral (2.60: 3.40), Agree (3.40: 4.20) strongly agree (4.20: 5.00)

	Mean Weighted Value	**Rank**
Financial Benefit	4.37	1st
Business Growth	4.21	2nd
Social security	3.75	3rd
Asset Acquisition	3.67	4th
Employment Opportunity	3.52	5th
Environmental Security	3.44	6th
Social Ties	3.22	7th
Recognition	2.19	8th

This is associated to short term loans and easy access to loans that members of some social networks enjoy. Business growth is ranked second with a mean value of 4.21, which could be due to larger markets opportunities that social networks offer, the women are able to have more opportunities to sales their goods and services. Also, social security is ranked high amongst the factors that determine participation in social network activities with a mean of 3.75 as it was observed from the women responses that that participation in social network activities which is a product of social network creates security in the social aspects of their livelihood activities. The list ranked Factor that influences participation in social network activities according to this survey is recognition with a mean value of 2.19.

Tangible Benefits of women participation in social network activities

The cumulative mean average was determined form analysis of the study to be 3.5; this was used as a benchmark against individual variables to determine the variables with much more social capital benefits as it regards the participation of women in social network activities. the survey reveals social network participation to have a very high tangible impact on the women in aspect of acquiring Food Products, with a mean value of 4.21 which is above the cumulative mean of tangible benefits from social network for this study, inferences can be made that through the social networks' activities and engagements of women they enjoy easy and cheap access to food produces.

The analysis reveals that ownership of sewing machine has also improved tremendously as it regards to the social Network activities participation of women in Gulu Vatsa Area with a mean value of 4.00, which is positively above the cumulative benchmark of 3.5. The benefits from social network participation is greatly felt also in the livelihood activities of women as it gives easy in access to ownership of Household appliances, grinding machine and landed properties.

Intangible Benefits from Women Social Network Participation Activities.

Analyzing the intangible the women of Gulu Vatsa area acquire from social capital participation reveals that large market opportunity is the highest variable from the analysis carried out with a mean value of 4.26, the survey was also able to establish that social network impact the livelihood activities in the area of access to information which had a mean value of 4.15,the value when put against the benchmark of 3.40 shows the high rate of positives social network has on creating security of the women livelihood.

The analysis reveals easy access to loans, environment security are also areas that social capital provides a source of livelihood security with the mean value of 4.05 and 4.03 respectively, this mean value further shows a glaring high difference against the cumulative benchmark of social capital impact adopted for this research.

Conclusion

The survey has been able to establish that different factors influences the participation of women in social network activities within the Gulu Vatsa Area, with social capital being a derivative of human social networks, the women of Gulu Vatsa area were discovered to engage and participate in different types of social networks for the different range of gains available to them within the study Area and its environs, gains ranging from ownership of household appliances, access to soft loans, wider market environment, access to information, social security and also ease in access to food produce.it is therefore recommended that the activities of this social networks be supported by the local government authorities.

Reference

Arora, S. & Meenu, M. (2010). Microfinance intervention: An insight into related literature with special reference to India. *American Journal of Social and Management Sciences, 1*(1), 44-54.

Boyd, M. (1989) 'Family and Personal Networks in International Migration', International Migration Review 23(3): 638–70.

Castles, S. and M. Miller (2003) The Age of Migration: International Population Movements in the Modern World. Basingstoke: Palgrave

Datta, Debajit R.N. Chattopadhyay and Shovik Deb, 2010. Prospective Livelihood Opportunities from the Mangroves of the Sunderbans, India. Research Journal of Environmental Sciences, 5: 536-543.

Faist, T. and E. Ozveren (eds) (2004) Transnational Social Spaces: Agents, Networks and Institutions. Aldershot: Ashgate

Isaac, I., Habila, J., & Ogwu, R. O. (2019b). *Access to assets: Livelihood deprivation among women in Isoko North Local Government Area, Delta State.* A paper presented at the 2019 International Conference: Contemporary Issues in Social Science Research, held at Faculty of Social Sciences, Kaduna State University. ISSN: 2319-7706 Volume 7 Number 03 (2018) Journal homepage: http://www.ijcmas.com

Kyeremeh Kwame Mensah (2014). Assessing the livelihood opportunities of rural poor households: a case study of asutifi district. A Thesis Submitted to the Department of Planning, Kwame Nkrumah University of Science and Technology Kumasi, Master of Science in Development Policy and Planning. Department of Planning College of Architecture and Planning

Maclean, K. (2010). *Capitalizing on Women's Social Capital? Women-Targeted Microfinance in Bolivia. Development and Change, 41(3), 495–515.* doi:10.1111/j.1467-7660.2010. 01649.x

Martins V I. (2019) Appraisal of the Role of Social Capital in Livelihood and Space Development In Minna, Niger State (PhD Thesis) Department of Urban and Regional Planning, Federal University of Technology Minna

Morse, S., & McNamara, N. (2013). *Sustainable livelihood approach: A critique of theory and practice.* Dordrecht: Springer Science + Business Media

Niger State Bureau of Statistics (2012) Educational Statistics Printed Under the Auspices of Nigeria Statistical Development Project (NSDP)

Okpukpara, B. (2009). Microfinance paper wrap-up: Strategies for effective loan delivery to small scale enterprises in rural Nigeria. *Journal of Development and Agricultural Economics, 1*(2), 41-48.

Putnam, R.D. (2007) '"E Pluribus unum": Diversity and Community in the Twentyfirst Century. The 2006 Johan Skytte Prize Lecture', Scandinavian Political Studies 30(2): 137–74

Rahman, S., & Akter, S. (2012). *Determinants of Household Livelihood Security in Poor Urban Settlements in Bangladesh.* A paper was presented at the 84th Annual Conference of the Agricultural Economics Society (UK) held at the Royal Agricultural College, Edinburgh, UK during March 29-31, 2010.

Rutendo Biza (2017) impact of livelihood skills training programs on youth development in wedza district. Midlands state university

Schraven B., Rademacher-Schulz C. (2016) Shifting Rainfalls, Shifting Livelihoods: Seasonal Migration, Food Security and Social Inequality in Northern Ghana. In: McLeman R., Schade J., Faist T. (eds) Environmental Migration and Social Inequality. Advances in Global Change Research, vol 61. Springer, Cham

Scoones, I. (2009). Livelihoods perspectives and rural development. *Journal of Peasant Studies,* 36 (1), 171–196

Shyamalie, H.W., & A.S. (2010). Livelihood Security of Women in Hills: A Comparative Study of India and Sri Lanka. *Indian Journal of Agricultural Economics,* 65(4), 710-721

Vincent, K., & Cull, T. (2010). *A Household Social Vulnerability Index (HSVI) for Evaluating Adaptation Projects in Developing Countries.* A paper presented at PEGNet Conference 2010: Policies to foster and sustain equitable development in times of crises, Midrand, 2-3rd September 2010

Socio-Economic Characteristics of Slum and Informal Settlement in Akure, Ondo State, Nigeria

Adedeji A.A.[1a], Junaid, A.M.[1b] & Sanni L.M.[1c]

[1]*Department of Urban and Regional Planning, Federal University of Technology, Minna, Nigeria*

[a]dejyem986@gmail.com, [b]asimiyu.junaid@futminna.edu.ng, [c]sanni.lekan@futminna.edu.ng

Corresponding email: dejyem986@gmail.com

Abstract:

The slum environment and informal housing have become entrenched in the developing worlds of Africa, Latin America, and Asia, where governments, nongovernmental organisations, and international agencies have failed to adequately control people's unceasing activities in some of the world's slum areas. In this paper, the socio-economic characteristics of residents in slums and informal housing developments in the core and peripheral areas of Akure were investigated. Data on socio-economic characteristics were gathered using questionnaires, personal interviews, and direct observation. Some of the socio-economic attributes considered were the monthly income of the respondents, house rent per month, household size of the respondents, and the number of people per room, among others. A simple random sampling technique was used in selecting the residents in the corridors selected in the study areas for questionnaire administration. A total of 696 respondents were sampled, and the questionnaire was administered to the household head of the selected houses. The findings revealed that over 70% of the respondents earned ₦ 60,000 or below. Also, there is a significant statistical relationship between the average monthly income and the average amount spent on rented residential housing. This means that the income of residents in the core and peripheral areas of Akure greatly influences how much is paid for housing. The findings also revealed that over 90% of the respondents had a household size of 3 members or above, and an average household size of 6 people was found for the residents of the core and peripheral areas of Akure. The findings revealed that over 80% of the respondents stayed in rooms with an occupancy ratio of 1:3 or above. The paper recommends synergy between the government and the residents of the core and peripherial areas of Akure by giving them loans with little or no interest to boost their businesses to enhance their monthly income, and thereby improve their living environment.

Keywords: Core, Development, Informal Housing, Peripheral, Slum

Introduction

Urban slums are undeniably one of the most prominent and distinguishing elements of the world's developing nations. The world's fast urbanisation has been the topic of much discussion, owing to the horrible living circumstances of the vast majority of urban slum dwellers. According to the United Nations Department of Economic and Social Affairs (UNDESA, 2014), by 2050, 66 percent of the world's population will be living in cities, up from a meagre 30% in 1950. Substantial demographic changes are happening in urban areas of some emerging countries, whose populations will continue to climb in the twenty-first century owing to industrial development and capital expansion (Okafor and Onuoha, 2016). While the population of the most industrialised countries seems to remain stable, urban populations in Africa and Asia, most of whom live in slums or squatter settlements, are rapidly increasing. Asia and Africa are expected to account for 86 percent of global population growth over the next four decades (UNDP DESA, 2011).

Asia's urban population is expected to grow from 1.9 billion to 3.3 billion people by 2050, while Africa's urban population will grow from 414 million to 1.2 billion. India, China, Nigeria, the United States, and Indonesia are expected to generate 497, 341, 200, 103, and 92 million people by 2050 (UNDESA, 2011). Different writers regard and understand housing in different ways. According to Jinadu (1995), housing may be more than simply a place to sleep; it can also be more than just a place to keep one's belongings. "Its idea has therefore gone beyond the traditional perspective of four walls and a roof structure to shelter man from the elements of nature" (Jinadu, 2007). The emergence of slums and informal housing is a result of the urban poor's desperate desire to satisfy this basic demand. Housing significantly impacts the community's health, efficiency, social behaviour, contentment, and overall well-being as a unit in the environment. It is the finest physical and historical proof of a country's civilisation and represents a society's cultural, social, and economic ideals.

According to Omole (2010), housing difficulties have an impact on both individual and national lives, and so both nature and society place a high value on the role they play in ensuring human comfort. In any nation, the necessity of providing enough and high-quality housing cannot be exaggerated or overestimated in space or time. It boosts the economy of the country. However, the cyclical nature of housing demands and the insatiable need for decent housing appear to corroborate the belief that few societies have adequately met their housing needs (Omole, 2010). Several factors are responsible for the spread of shanties, squatter communities, informal housing, and slums in most of Nigeria's cities and other developing countries. Naturally, such issues are linked to the residents' poor socio-economic and cultural status. This paper, therefore, intends to investigate the socio-economic characteristics of residents of slum and informal housing developments in the core and peripheral areas of Akure, Ondo state.

The Study Area

Akure is a traditional Nigerian city and, like other traditional Yoruba towns in the country, existed long before the advent of British colonial rule. The city is located within Ondo State in the South Western part of Nigeria. Ondo State is one of Nigeria's 36 states, as shown in Figure 1. Akure is a medium-sized urban centre and became the provincial headquarter of Ondo province in 1939. It also became the capital city of Ondo State and a Local Government headquarters in 1976. Ondo state is located approximately 700 kilometres South West of Abuja, the Federal Capital of Nigeria and about 350 kilometres to Lagos, the former capital of Nigeria. Akure is the capital of Ondo State and the headquarters of Akure South Local Government Area. It lies between longitude 5°06'E and 5°38'E and between latitudes 7°07'N and 7°37'N in Southwestern Nigeria (Olajumoke et al., 2016). The city is located 396 metres high above sea level. According to the Nigeria population census (2006), Akure has a population of 360,268. Thus, the current estimated population is about 495,000 using a growth of 3%.

Methodology

This research work was conducted in three phases: data acquisition, analysis, and post-analysis, respectively. The first phase is the information and data gathering phase. Important data, both primary and secondary, were gathered to carry out the research. Descriptive and inferential statistics were applied to the data, including frequency, percentages, cross-tabulation, and chi-square. The sampling technique most suited for the study was a combination of two techniques: stratified sampling and simple random sampling. The stratified sampling method was used in selecting the corridors. This was based on those corridors that exhibit slum and informal housing characteristics, e.g., lack of basic services, substandard housing, illegal and inadequate building structures, insecure tenure, poverty and social exclusion, and overcrowding due to high density. A simple random sampling technique was used in selecting the residents in the corridors selected both in the study area for questionnaire administration (a total of 696 respondents were sampled and the questionnaire was administered to the household head of the selected houses).

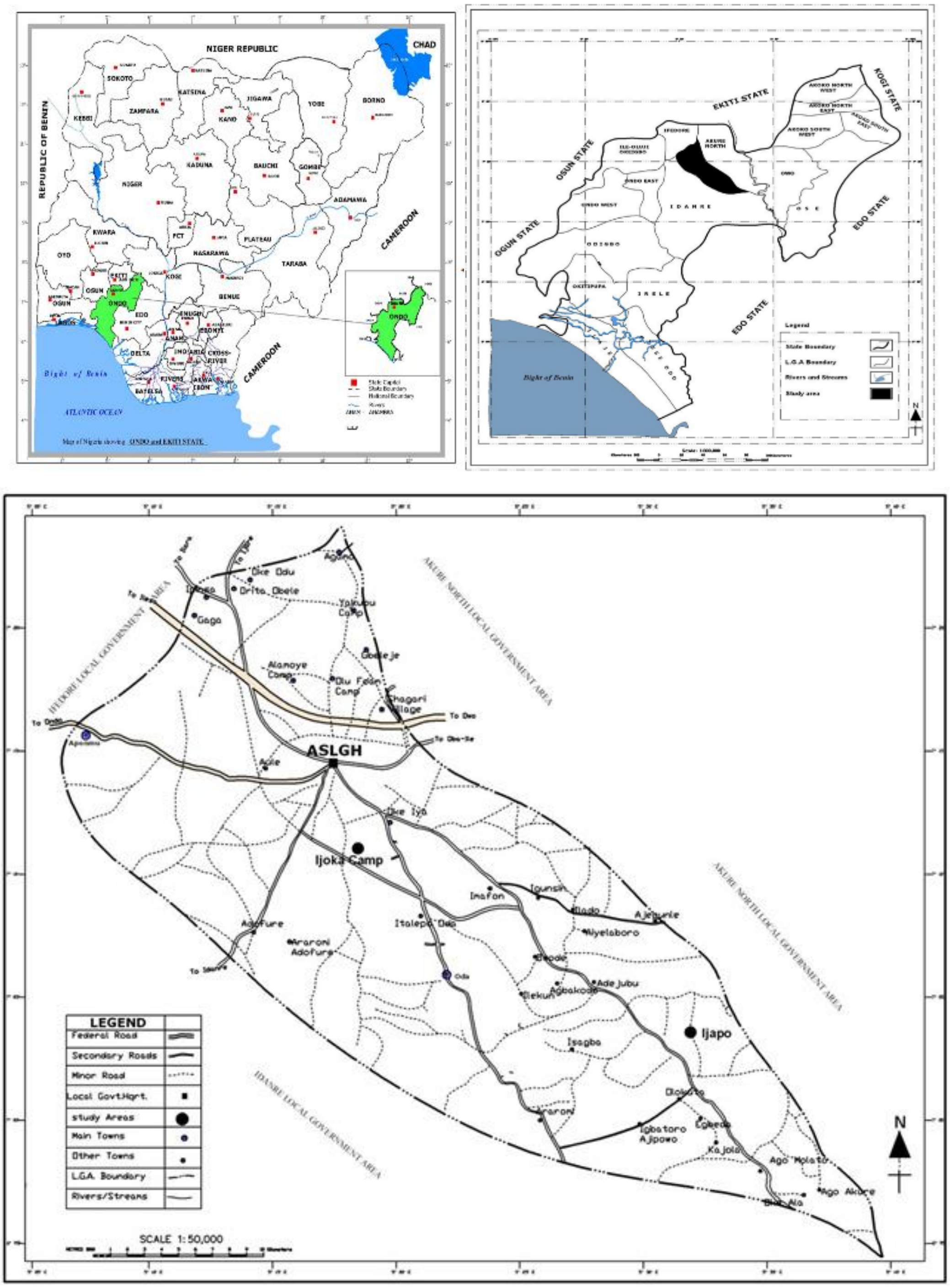


Figure 1. *Map of the study area.*

Data Analysis

Monthly income of the respondents

The result of the field survey, as shown in Table 1, indicates that 29.2% of the respondents earned more than ₦10,000 – 20,000 monthly, while 28.3% of the respondents earned between ₦21,000 and 40,000. Those that earned between ₦41,000 and 60,000 were 14.2%, while those that earned between ₦61,000 and 100,000 were 18.3% of the respondents. The remaining 10% earned above ₦100,000. According to the cumulative Percentage in Table 1, the majority of respondents (60.8%) earned ₦60,000 or less per month.

President Muhammadu Buhari in 2019, signed into law to increase Nigeria's monthly minimum wage to ₦30,000 ($73) from ₦18,000, which is now the current approved minimum wage by the Federal Government of Nigeria. Since 2015, the World Bank has defined extreme poverty as people living on less than $1.90 a day, measured by using the international poverty line. In other words, most of the respondents (71.7%) can be classified as extremely poor because they live on less than $1.90 (₦782) a day.

This finding here agrees with the study by Victor (2014) on an appraisal of housing conditions in the residential core area of Akure, where it was revealed that the majority of residents of the core area and the peripherals of Akure are low- and medium-income earners with a monthly income of less than ₦20,000. This finding is important to this study because, with a higher income, there is more disposable income with which to procure decent housing. This means the urban poor households are more concentrated in the core areas of Erekesan, Oja Oshodi, Odo Ikoyi, Ijomu, Alakure, Idiagba, Ilemo, Eyinke, and Arakale of Akure.

Table 1: Monthly income of the respondents

Monthly income	Frequency	Percentage	Cumulative Percentage
₦10,000-20000	175	29.2	28.3
₦21,000-40,000	170	28.3	46.7
₦41,000-60,000	85	14.2	60.8
₦61,000-100,000	110	18.3	90.0
Above ₦100,000	60	10.0	100.0
Total	600	100.0	

House rent per month

Table 2 shows the house rent paid per month by the respondents in the study area. The findings revealed that 37.5% of the respondents paid between ₦1000 and 2,500 monthly, while 28.3% and 28.3% paid between ₦2,501-5,000 and ₦5,001–7,500, respectively. The remaining 5.9% of the respondents paid between ₦7,501 and 10,000.

Table 2: House Rent per Month

House rent per month	Frequency	Percentage
₦1,000-2,500	225	37.5
₦2,501-5,000	170	28.3
₦5,001-7,500	170	28.3
₦7,501-10,000	35	5.9
Total	600	100.0

Table 3 was used to deduce the association between how much a core and peripheral resident avails for accommodation based on accrued income. The two variables were measured as nominal data. The output of the Chi-square analyses presented in Table 3 shows that the Pearson Chi-square statistic (f) = 386.263, p-value = 0.000 ($p > 0.05$). This derivation indicates that the variables are dependent, thus providing enough evidence to infer a significant statistical relationship between the average monthly income and the average amount spent on rented residential housing in the metropolis. This means that the income of residents in the core and peripheral areas of Akure greatly influences how much is paid for housing.

The cross-tabulation executed and presented on Table 4 supports the outcome of the Chi-square test and buttresses the situation in the study areas. The findings show that 70.6% of residents who spent more than 1,000 Naira on rent on a monthly basis earned between 10,000 and 20,000 Naira, and no resident earned between 1,000 and 2,500 Naira paid more than 7,500 Naira for rent on a monthly basis. In addition, 72.7% of respondents who earned between 21,000 and 40,000 Naira monthly spent between 1,000 and 2,500 Naira monthly on rent, while 13.6%, 9.1%, and 4.5% of residents who earned within the same category spent between 2,501-5,000, 5,001-7,500, and 7,501-10,000 Naira monthly on rent, respectively.

Table 3: The relationship between average monthly income and expenditure on housing

Chi-Square Tests	Value	Df	Asymptotic Significance (2-sided)
Pearson Chi-Square	386.263[a]	16	.000
Likelihood Ratio	389.071	16	.000
Linear-by-Linear Association	208.366	1	.000
N of Valid Cases	600		
a. 8 cells (32.0%) have expected count less than 5. The minimum expected count is 1.00.			

Furthermore, 70.6% of respondents who earned between 41,000 and 60,000 Naira per month spent between 2,501 and 5,000 Naira per month on rent, while 5.9%, 17.6%, and 5.9% of residents who earned within the same category spent between 1,000-2,500, 5,001-7,500, and 7,501-10,000 Naira per month on rent, respectively. Furthermore, 54.3% of respondents who earned between 61,000 and 100,000 Naira per month spent between 5,001 and 7,500 Naira per month on rent, whereas 31.4%, 8.6%, and 5.7% of residents who earned the same amount spent between 2,501-5000, 1,000-2,500, and 7,501-10,000 Naira per month on rent, respectively. Finally, 50.0% of respondents who earned above 100,000 Naira monthly spent between 5,001 and 7,500 Naira monthly and 25.0%, 16.7%, and 8.3% of residents who earned within the same category spent between 7,501 and 10,000, 2,501-5000, and 1,000-2,500 Naira monthly on rent, respectively. The findings from Table 4 suggest that a significant proportion of the respondents' monthly income was spent on rent. This finding agrees with that of Junaid (2017), which asserted that urban poor are those who spend a significant proportion of their income on housing.

Table 4: Average monthly income and expenditure on rented residential housing cross-tabulation

Monthly Income	₦1,000-2,500	₦2,501-5,000	₦5,001-7,500	₦7,501-10,000	Total
₦10,000-20000	120	30	20	0	170
	70.6%	17.60%	11.80%	0.00%	100.00%
₦21,000-40,000	80	15	10	5	110
	72.7%	13.60%	9.10%	4.50%	100.00%
₦41,000-60,000	5	60	15	5	85
	5.9%	70.60%	17.60%	5.90%	100.00%
₦61,000-100,000	15	55	95	10	175
	8.6%	31.40%	54.30%	5.70%	100.00%
Above ₦100,000	5	10	30	15	60
	8.3%	16.70%	50.00%	25%	100.00%
Total	225	170	170	35	600
	37.5%	28.30%	28.30%	5.90%	100.00%

Household Size of the Respondents

Table 5 shows the distribution of respondents based on their household size. The result revealed that 46.7% of the respondents in the study area had between 5-7 members in their household, while 22.5% had 8 members or more. Also, 24.2% of the respondents had 3–4 members in their household, and the remaining 5.8% of the sampled respondents had a household size of 2 members.

The finding here agrees with the findings of Olajuyigbe *et al.* (2015) on slums in the urban core of Akure, Nigeria, which revealed that 45.1% of the respondents sampled had between 5-7 people per household. This study discovered a similar trend, as 46% of the respondents sampled had between 5-7 people per household.

Table 5: Household size of the respondents

Household size	Frequency	Percentage
1 person	5	0.8
2 persons	35	5.8
3-4 persons	145	24.2
5-7 persons	280	46.7
8 persons and above	135	22.5
Total	600	100.0

Conclusion and Recommendation

This study has identified the socio-economic characteristics of residents in slums and informal housing in Nigeria as epitomised. It has presented detailed information on the monthly income, house rent, and household size of the respondents in Oba-Ile, Oja Oshodi, Ijomu, Alakure, Idiagba, Ilemo, Eyinke, and Arakale of the core area, and Igoba, Ijoka, and Orita Obele of the peripheral areas. The following are some of the policy recommendations resulting from this study. There should be synergy between the government and the residents of the core and peripheral areas of Akure by giving them loans with little or no interest to boost their businesses, enhance their monthly income, and improve their living environment. The government at all levels (federal, state, and local) should develop the surrounding rural areas to reduce the rural-urban migration that was found to be one of the causes of migration to this area.

References

Ayuba, M. R. (2019). *Slums Proliferation In Nigeria: Exploring The Spatial Manifestations, Formations And Implications.* A published post graduate thesis submitted to Department of Sociology, Faculty of Social Sciences, Ahmadu Bello University, Zaria.

Faniran, S. and Olaniyan, K. (2013). From Slums to Smart Cities: Addressing Slum Dwelling in Nigeria through e-Land Administration, *ICEGOV2013* Seol, Korea.

Grigg, V. (2010). http://www.urbanleaders.org/weburbpoor/04Context (CX)/urban%20 slum definitions.htm

Jinadu A.M (1995). *Forced Eviction, Relocation and Urban Poverty*; A case study of Maroko in Lagos, Nigeria. Unpublished MURP dissertation submitted to the centre for urban and regional planning, university of Ibadan, Ibadan, August,1995.

Jinadu A.M (2007). *Understanding the basic of housing*, Jos University Press L.T.D. Jos Plateau State.

Jinadu A.M (2017). Inaugural lecture series 51, Presented at Federal University of Technology Minna.

Olajuyigbe Ayo Emmanuel, Olusola Olalekan Popoola, Suleiman Abdul-Azeez Adegboyega & Tayo (2015). Application of Geographic Information Systems to Assessing the Dynamics of Slum and Land Use Changes in Urban Core of Akure, Nigeria. *Journal of Sustainable Development; 8 (6)* ISSN 1913-9063 E-ISSN 1913-9071

Okafor, B.N. and Onuoha, D.C. (2016). The Effect of Slum on Property Values in Asaba Metropolis of Delta State. *British Journal of Environmental Sciences* Vol.4, No.3, pp.17- 33

Omole KF (2010). An Assessment of Housing Condition and Socio-Economic Life Styles of Slum Dwellers in Akure, Nigeria. Contemporary Management Research, 6(4),272-290.

Owoeye, J.O and Omole, F.K (2012). Built Environment Decay and Health Situation of Slum Dwellers in Residential Cores of Akure, Nigeria in *America Journal of Human Ecology;* 1(2), 33-39

UN-DESA (2014) *Gender Equality for Smarter Cities: Challenges and Progress* (Nairobi: UNHabitat) http://unhabitat.org/books/gender-equality-for-smarter-cities-challengesand progress/

UN-Habitat, (2003). Slums of the World: The face of urban poverty in the new millennium?*Working paper*, United Nations Human Settlements Programme (UN-HABITAT), Nairobi, Kenya,

UN-Habitat. (2008). *2nd African Ministerial Conference on Housing and Urban Development.* Geneva. UN Press.

UNPD-DESA, (2011). *Revision of the World Urbanization Prospects*, produced by United Nations Population Division of the Department of Economic and Social Affairs, New York.

Victor, A. (2014). An Appraisal of Housing Conditions in Residential Core Area of Akure City in South Western Nigeria: A Case Study of Arekesan. *International Journal of Advanced Scientific Research and Management,* 1 (7) ISSN 2455-6378

Impact of protest in Lagos state as an emerging mega city: A Review

Malik, A.A.[1a] & Bilau, A.A.[1b]
[1]Department of Building, Federal University of Technology Minna, Niger State. Nigeria
[a]abdulwolia@gmail.com; [b]aabilau@futminna.edu.ng
corresponding author: abdulwolia@gmail.com

Abstract:

The frequency of occurrence of large-scale protests has increased in the past decade especially in developing countries. This has increased the attention of leaders and stakeholders and has thus increased the need to manage these protests as it affects the growth and development of nations. Nigeria has a history of these protests which mostly have been found to have consequential effects in the country's-built environment especially when it turns violent. In order to comprehend the effects of these protests in the built environment, this study reviews its impacts on schools, bridges and other public infrastructures in Nigeria's most populous state and economic hub: Lagos state which is an emerging mega city and the epicentre of most of the protests. The review concludes that politics, corruption and socioeconomic issues are part of the causes of these protests in Nigeria. Findings in this work will help to enhance the knowledge on the impacts of protests so as to guide policy makers on the approach to take when addressing the protests and other social movements.

Keywords: Built Environment, Impacts, Emerging Mega City, Social Movements, Protests.

Introduction

A protest is a type of revolutionary social movement which involves an expression or proclamation of objection, disapproval or dissent often in opposition to something that a person cannot stop or avoid (Akintola, 2010). It implies the airing of a grievance with the implication of opposition to certain causes. It is a common way for citizens to participate in politics, a persistent problem for political leaders, and a potential source of countervailing power for the weakest members of the society. According to Alexander (2018), protests are demonstrations during which a particular defined and recognized group makes a set of collective demands and frames those requests in favour of or in defence of that community.

Studies by Ortiz *et al*. (2022) shows that the most consistent reason for people around the world to protest is the perceived failure of democracies. About 54% of all protests considered between 2006 and 2020 (a total of 1503 protest events overall) relate to a failure of political representation and of political systems. According to Article 11 of the African charter on Human and people's rights and other international legislation, protests are generally seen as a legitimate way to engage in politics. However, due to the rising tide of terrorism and violence around the world, various nations have recently created, interpreted and used a variety of domestic laws to control protest marches and political gatherings in public areas (Segun, 2015).

Nigeria with a population of more than 200 million and hosting more than 250 ethnic groups is the most populated country in Africa. This diverse culture and believes of the country have made it very prone to different kinds of social movements. Protests in Nigeria have existed for centuries now. They have been part of a deliberate and peaceful nonviolent and sometimes violent effort to attain a specific goal, and include the use of both pressure and persuasion; they are more accurately classified as incidents of civil resistance or nonviolent resistance (Adam, 2009). Sometimes, Government policies, economic circumstances, religious orthodoxy, societal institutions, or media monopoly have been the major causes of protests which most at times result in a disastrous impact on the country's-built environment.

A handful of literature has been seen on how various protests have occurred in many societies and how they may bring about different forms of changes in many sectors of the society especially the built environment of cities. However, from the papers reviewed, it was noted that only a little work has been conducted to assess the impact of protest in any emerging mega city which this paper seeks to fill. This is done by focusing on issues that have not been sufficiently addressed by following the nature which the various episodes of protests in Nigeria have taken and studying how it impacts on the growth of

Lagos State, Nigeria's most populated city and the epicentre of most of the protests as an emerging megacity.

Selected Trend of Popular Protests in Nigeria

Protests and other forms of demonstration have always been a fundamental component of the Nigerian society. These protest activities have either caused a clear shift in the system or further ignited a larger chain of events since the colonial era, long before the country gained independence (Adebowale, 2020). A selected trend of popular protest recorded in Nigeria includes:

Aba women's riot in 1929

The aba women's riot of 1929 was a two-month uprising led by market women from the Igbo tribe of southeast Nigeria. Women in the Igbo culture were exempt from paying tax, so the imposition of an oppressive tax policy on them served as the impetus for the uprising. The most significant challenge to British control in the colony's history was launched when thousands of Igbo women as shown in figure 1 organized a huge uprising against the policies implemented by the British colonial administrators in south eastern Nigeria. The government struggled for months to put an end to the women's war which went down in history as a feminism and anti-colonial resistance (Enyioko, 2021).

Figure 1. Aba's women riot (Adebowale, 2020)

Colonial authorities abandoned their attempts to tax market women and restrain the authority of the warrant chiefs as a result of the aba women's war. The women's uprising led to the destruction of government infrastructure in in the markets and other areas where it took place.

Ali Must Go of 1978

During the military regime of General Olusegun Obasanjo, the slogan "Ali Must Go" was used in opposition to Col. Ahmadu Ali, the then federal commissioner of education. This was due to the hike in the cost of meal ticket for students in higher institutions from 50kobo to 1.50obo and later to N2.00 which spared the protest and that resulted in scores of student deaths (Adebowale, 2020).

The protest as shown in Figure 2 had students from several tertiary institutions around the country injured and some others killed was led by late Segun Okeowo, the president of National Union of Nigerian Students (NANS). The protest on the first day was peaceful in all campuses including University of Jos which hosted the headquarters of the students union however, on the second day, university of Lagos students woke up to find their institutions gate blocked by a sizeable number of armed police officers even though they had intended to deliver a protest letter containing their demands to General Obasanjo at his headquarters in dodan barraks on that day as they planned to peacefully leave the campus unarmed (Madunagu, 2017). This students' revolt led to a wide spread looting, damage of several institutions infrastructures and injuring of not less than twenty students of tertiary institutions in the country and even death of unnamed students (Ojo, 1980).

Figure 2 UniLag students during Ali must go protest (Omipidan, 2020)

1989 Anti-SAP riots

The structural adjustment programmme (SAP) which was rolled out by the federal government of Nigeria between 1986 and 1991 was characterized by widespread protests, much of which was directed at its implementation prescribed by the World Bank and the International Monetary Fund. The justification put forward for the introduction of SAP was that the program would stabilize the national currency; restructure and diversify the productive base of the economy and reduce overdependence on the oil sector; reduce the dominance of unproductive public sector investment and enhance the growth potential of the private sector.

Instead of improving the economy, a turn for the worst was experienced in the country's economy. This resulted in a drastic cut in educational budgets and funding to universities, increased inflation, devaluation of the Naira, and high rate of unemployment which prompted various forms of resistance by staff and students in the schools, with the staff struggling against their deteriorating welfare and working conditions and the students embattled by their despicable accommodation facilities and learning environment. This led to a very serious resistance by the student unions and members of the academic and non-academic staff of universities and other civil society groups.

June 12 protest in 1993

This protest took place after the annulment of the 1993 elections that indicated a victory for Moshood Kashimawo Olawale Abiola of the then Social Democratic Party (SDP) as the winner of the elections defeating Bashir Tofa, the flag bearer of the National Republican Convention (NRC) (Ogbeidi, 2010). Although the result of the election was not officially declared by the electoral commission due to electoral irregularities cited by General Ibrahim Babangida, the then military ruler of Nigeria.

Figure 3 Protesters in Lagos after the annulment of June 12 1993 elections (Sahara Reporters, 2021)

This however led to a serious political unrest as captured in figure 3 that caused loss of lives and properties. An estimated 14 million Nigerians participated in the election and was seen as the free and fair (Adejoh, 2016) and the protest had more than 30 percent of the voter population in attendance.

Occupy Nigeria protest of 2012

The occupy Nigeria protest as shown in Figure 4 was a response to the Nigeria's government abrupt rise in the price of the premium motor spirit (PMS) from N65 to 140 which coincided with the Arab spring and the global occupy protests which followed this uprising. The social media compelled international media focus on Nigeria as a result; it was not unusual for this kind of protest to be first seen as a continuation of the worldwide demonstrations against government excesses that had started with the Arab spring. this protest however led to the destruction of government and political party buildings

Figure 4 A crowd holding a banner that reads "Nigeria rally against corruption" during a protest in Lagos (Meza, 2012)

The #EndSars protests of 2020

The #EndSars protest as shown in Figure 5 started as a call for the disbandment of Nigeria's Special Anti-Robbery Squad (SARS), a unit of the Nigerian Police Force that was well known for its notoriety in terms of civilian brutality and human rights violations. The protest began as a request to abolish the special anti-robbery squad (SARS) of the Nigerian police force, a division well known for its brutality and breaches of human rights (Omonobi, 2018). The #EndSars campaign started around 2017 as a twitter campaign and awareness began to spread over the claims that SARS officers engeged in violence and exploitatiion of young people (Salaudeen, 2017; Samuel, 2018). In the year 2020 around october, reports of an unpprovoked shooting of a youngster by SARS agents in delta state Nigeria was made, this was thus propagated by social media users particularly twitter. This caused an uprising in different parts of the country leading to destruction of properties worth billions and lost of lives (Uwazuruike, 2020). this movement geberated about 28 million tweets on tweeter alone (Yomi, 2020). the EndSARS resulted in Vandalization of properties in shops and destruction of market infrastructures in major cities of the country.

Figure 5: The famous 2020 End SARS protest across Nigeria (BBC, 2020))

Impacts of Protests on the Built Environment of Mega Cities

During the period 2006–2020, the world has experienced some of the largest protests in its history (Ortiz et al., 2022). However, the largest protest recorded in Nigeria in the 21st century is the 2020 EndSars protests against the Nigerian police force special anti-robbery squad, which is estimated to have involved millions of protestors both within and outside Nigeria (Busari, 2020). These impacts on infrastructures of mega cities are thus discussed below.

Industrial Buildings

Violent protests such as riots, looting and vandalism have a serious impact on buildings and its occupant's safety. These events disrupt businesses; lead to road closures, and puts lifelong investments at risk. Private and public buildings are targets during violent protests. an example as shown in Figure 6 where the recent End SARS protest where protesters damaged fewer than 27 buildings, including police stations, media houses, government secretariats, NPA building.

Figure 6: Burning of the NPA building in Marina (Akinrefon, 2020)

Bridges

Through public marches, protests are a way to have disagreements or vent anger. During violent disagreements, bridges and other public infrastructures are at risk of damage. This is evident in violent protests that have been witnessed especially in Lagos where the lekki-Ikoyi Link bridge toll gate as shown in Figure 7 was razed by EndSARS protesters after soldiers were alleged to have opened fire on the EndSARS hoodlums.

Figure 7: Screen shot of video clip showing all cubicles of link bridge toll gate burning during EndSARS protest (Sahara Reporters, 2020)

Social Infrastructure

Social infrastructures are construction and maintenance facilities that support social services. Social infrastructures including bus parks, transportation systems, malls and other infrastructures are destroyed during violent protests. This is shown in Figure 2.8 where buses at oyingbo bus terminal were destroyed during the EndSARS protest in Lagos state.

Figure 8: Lagos state bus terminals at Oyingbo, Yaba and Berger set ablaze (Adediran, 2020)

Public Buildings

Public buildings such as bus parks, schools, train stations, recreational centres, banks and, courts are soft spots during violent conflicts (Vanguard, 2020). This is seen in Figure 9 where violent conflicts recorded in Lagos state during the occupy Nigeria and EndSARS riots resulted to burning of the oldest court in Nigeria. Educational infrastructures in schools are usually a target by Students and violent protesters because they have been seen as properties of the government and school authorities.

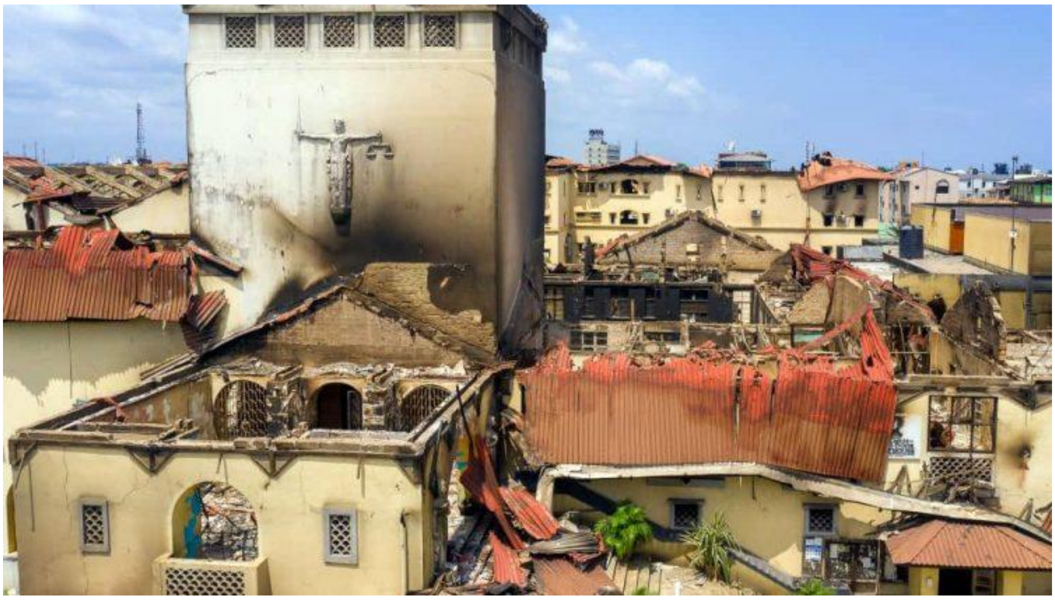


Figure 9: the oldest court in Nigeria, the Federal High Court at Igbosere, Lagos being burnt (Adediran, 2020)

Table 1 shows the impact of well-organized groups, as they have mobilized the majority of these protests;

Table 29: summary of the impacts of protest in Nigeria from 1929 to 2022

SN.	Protest	Year	Impacts	Reference
1	Aba women's riot	1929	Affected trade through destruction of government infrastructure and factories Vandalization of about sixteen native administration buildings Looting of factories and ten native courts.	(Enyioko,2021; Chukwuemeka,2020)
2	Abeokuta women's revolt	1946	Increased participation of women in the local council. Influenced the economic role of taxation of women under colonial rule.	(Byfield, 2013)
3	Ali must go	1978	wide spread looting loss of several institutions' infrastructures injury and death of not less than twenty students	(Madunagu,2017; Adebowale,2020)
4	Anti-SAP riot	1989	burning of petrol stations Influenced the provision of SAP relieve measures like employment of graduates. Burning of market infrastructures Widespread looting leading to loss of properties. Influenced reduction of fuel prices.	(Micheal,2021; Pauline,1990)
5	June 12	1993	Destruction of government owned buildings. Influenced reduction of fuel prices. Destruction of government and political party buildings.	(Adejoh, 2016)
6	Occupy Nigeria	2012	Vandalization of properties in shops and market infrastructures. Damaged roads and bridges. Government infrastructures destroyed.	(Meza, 2012; Egbunike, 2020)
7	End-SARS	2020	Disbanding SARS due to increased injuries recorded and properties damaged.	(Uwazuruike, 2020)

Emerging Mega Cities

There are various definitions of what constitute a mega-city depending on the parameters used. United Nations define mega city as a city with population of 10 million persons and above (Obia, 2016), whereas Kraas, et al. (2005) puts the figure at 5 million. However, the expression has been used in Canada and other places to refer to conurbation of cities or communities that have hitherto been isolated but have circumstantially grown to link themselves.

According to Kraas *et al.* (2005), mega cities are generally classified into three categories. These include those that are experiencing very rapid population growth, have outdated or non-existent infrastructure, and are located in developing countries or emerging markets. Examples of such cities include Mumbai (India) and Lagos (Nigeria). The second class involves those cities that are experiencing economic growth, establishing or transforming their infrastructure, already have strong economies and are undergoing a transition to developed cities, example of which include Shanghai (China) and Beijing (China). A third category includes those that are already developed and have strong and good infrastructure. In this group are found New York (America), Tokyo (Japan) and London (Britain), the alpha cities. Table 2 presents an excerpt of population size and urban agglomerations of this categories of megacities and that of others emerging around the world.

Table 30: Excerpt of population size and urban agglomerations as of 1 July, 2014

Rank	Megacity	country	continent	Population	Annual growth
1	Tokyo	Japan	Asia	37,833,000	0.6%
2	Delhi	India	Asia	24,953,000	3.2%
3	Shanghai	china	Asia	22.991,000	3.40%
4	Mumbai	India	Asia	20,741,000	1.60%
5	Osaka	Japan	Asia	20,123,000	0.80%
6	Beijing	China	Asia	19,520,000	4.60%
7	New York City	USA	N. America	18,591,000	0.20%
8	Cairo	Egypt.	Africa	18.419,000	2.10%
9	Buenos Aires	Argentina	S. America	15,024,000	1.30%
10	Rio de Janeiro	Brazil	S. America	12,825,000	0.80%
11	Lagos	Nigeria	Africa	12,308,000	0.20%
12	Moscow	Russia	Europe	12,063,000	1.20%
13	Kinshasa	DRC	Africa	11,116,000	4.20%
14	Paris	France	Europe	10, 764,000	0.70%
15	London	United Kingdom	Europe	10,189,000	1.20%

Source: World urbanization prospects: the 2014 revision as cited in Obia (2016)

Each of the categories of countries presented here has one peculiar problem to face or another. While Tokyo, for instance will be struggling with the problems of aging population, Lagos is battling with the problems associated with slums and squatter settlements – poor health, squalid living conditions, insufficient/dilapidated infrastructure and poor waste management amongst others which could be a source of uprising and an inhibition to achieving the status of being a megacity.

About 28 settlements in the world are classified as mega-cities as at 2016. These 28 cities are homes to 453 million people - 12% of global population (United Nations, 2014). Approximately 95% global urban expansion is being driven by cities in developing countries and emerging markets (Obia, 2016). As at today, only three of this megacities-Lagos (Nigeria), Cairo (Egypt) and Kinshasa (Democratic Republic of Congo) are found in Africa.

Lagos state is Nigeria's largest megacity. It is located between latitudes 6° 23'N and 6° 41'N and longitudes 2° 42'E and 3° 42'N. Lagos state has been growing unsurprisingly despite the rising inequalities, chronic traffic jam describes as the "worst in the world" and growing crimes rate (Cheeseman & Gramont, 2017). This development has in turn generated a city of stark contrast where there are almost 10,000 millionaires in the state and around two third of lagosians live in slums. These differences and other government policies effect especially on the informal sector in this city could sometimes be thought to be responsible for the high crime rate and violent protests leading to destruction especially of social infrastructures.

Conclusions

In the recent decade it has been observed that protests in Nigeria have not only increased but also become more violent and destructive and most at times targeted at pubic infrastructures. Although the basic cause of most of these protests have been majorly found to range from politics, corruption and socioeconomic issues, other like urban land and housing, unemployment and police brutality are other issues that have led to these protests. Sometimes, many of the frequent and violent protests were caused by largely by unmet expectations for transformation required by citizens. This has to a large extent affected the growth of Lagos state as an emerging mega city in Nigeria which is usually the epicentre of these protests. These protests if not properly managed has severe influence on Lagos states effort to become a mega city. Laws aimed at deterring protesters from indulging in violence and damaging public infrastructures should be put in place. Also, adherence to the state master plan should be strict so as to reduce the impacts of violent protests are recommended moving forward.

References

Adam, R. (2009). *Civil resistance and Power Politics; the experience of Non- violent action from Gandhi to the present.* Oxford University Press.

Adebowale, O. (2020). *History of protests in Nigeria: Reactions and consequences.* Abuja, Nigeria: Life.

Adediran, I. (2020, October 25). How Hoodlums took advantage of EndSAR, wreaked havoc in Lagos. *Premium Times*.

Adejoh, P. E. (2016). The Impact of civil Society Groups in the June 12 1993 Elections. *Nigerian Journal of Applied Behavioural Sciences, 4*, 409-425.

Akinrefon, D. (2020, October 22). #EndSARS Protest:Board chairman condemns burining of NPA building. *Vanguard*.

Akintola, B. (2010). The Perils of Protest: State Repression and Student Mobilization in Nigeria. *Encountering the Nigerian State* (pp. 99-121). New York: Palgrave Macmillan.

Alexander, P., Runciman, C., Ngwane, T., Moloto, B., Mokgele, K., & van Staden, N. (2018). South Africa's community protests 2005–2017. *Frequency and turmoil, 63*, 27-42.

BBC. (2020). *End Sars: How Nigeria anti-police bustality protests went global.* Lagos: BBC.

Busari, S. (2020, October 27). Nigerias youth find its voice with the EndSARS Protest movement. *CNN*.

Byfield, J. A. (2013). "Taxation, Women, and the colonial State Egba Womens Revolt". *Meridians: Feminism, Race,, Transationalism., 3*(2), 250-277.

Cheeseman, N., & Gramont, D. (2017). Managing a megacityLearning the lessons from Lagos. *Oxford review of economic policy, 33*(3), 457-477.

Chukwuemeka, S. (2020). *7 Causes of Aba Womens Riot of 1929.* Uwani Enugu State, Nigeria: Bscholarly.

Egbunike, N. (2020). Social Media and the #OccupyNigeria Protests Igniting or damping a harmattan storm? *Journal of African Media Studies, 7*(2), 141-146.

Enyioko, N. (2021). Aba Womens Riot (November to December). *SSRN Electric Journal, 5*(8), 1-12.

John, A. (2022, June 29). ASUU Strike:NLC Nationwide Solidaruty Protest July 26. *LEADERSHIP*.

Kraas, F., Aggarwal, S., Coy, M., Heiken, G., Marker, B., Nenonen, K., et al. (2005). *Megacities – our global urban future*. Retrieved December 4, 2022, from yearofplaneteath.org : http:///www.yearofplaneteath.org

Madunagu, E. (2017, November 28). Ali must go and the Nigerian left. *The Guardian*, pp. 12-13.

Matta, S., Bleaney, M., & Appleton, S. (2021). The economic impact of political instability and mass civil protest. *Economic and Politics, 3*, 1-18.

Meza, A. (2012, January 11). Occupy Nigeria Fuel subsidy elimination triggers massive protests, deadly violence. *THESETIMES*, pp. 5-7.

Micheal, H. A. (2021). *Nigerian Austerity Program Causes Deep Political Discontent: Africa : The results could be significant to the rest of the continent.* Los Angeles: Los Angeles Times.

Obia, A. (2016). Emerging Nigerian Megacities and Sustainable Development: Case study of Lagos and Abuja. *Journal of Sustainable Development, 9*(2), 27-42.

Ogbeidi, M. M. (2010). A Culture of failed elections; Revisting Democratic Elections in Nigeria, 1959-2003. *Historia Actual Online, 21*, 43-56.

Ojo, J. D. (1980). The constitutional aspects of april 1979 students demostrations in the Nigerian Universities: A critical analysis. *Philliipine political science journal, 8*(12), 8-21.

Omipidan, T. (2020, July 16). See how 50 Kobo caused nationwide protest in Nigeria in 1978. *OldNaija*, pp. 4-6.

Omonobi, K. (2018, January 31). Anti-SARS Campaign IG orders investigation of anti-robbery squad. *Vanguard Newspaper*.

Ortiz , I., Burke , S., Berrada, M., & Cortés, S. H. (2022). *World Protests A Study of Key Protest Issues in the 21st Century.* New York: Palgrave Macmillan.

Pauline, E. M. (1990). *The Anti-SAP Upheaval in Nigeria.* Philosophy and Social Action.

Reid, J. (2022, February 22). Managing Building Safety and Security during nass PProtests. *Canadian Security*.

Sahara Reporters. (2020, October 20). Breaking: Leki-Ikoyi Link Bridge Toll Gate on Fire. *SAHARA REPORTERS*.

Sahara Reporters. (2021, June 12). Abiola, the adjudged winner of the June 12, 1993 presidential election died on july 7, 1998. *June 12: I was almost killed during 1998 unrest because they thought i was hausa, i wont ever return to Nigeria- Ghanian man*.

Salaudeen, A. (2017, December 15). Nigerian want police SARS force scrapped. *Aljazeera*.

Samuel, O. (2018, January 3). #EndSARS: Police mum as Nigerians recount attrocoties of Special Anti-Robbery Squad. *Premium Times*.

Segun, E. O. (2015). Protest demosntration, Political participation and the law in the era. *International Journal of Arts and Humanitarian (IJAH), 4*(2), 28-41.

United Nations. (2014). *World urbanization prospects: 2014 revision.* . New York: United Nations.

Uwazuruike, A. R. (2020). #EndSars: The movement against police brutality in Nigeria. *Harvard Human Rights Journal*, 1-6.

Vanguard. (2020, October 21). Remains of the Day: Property destroyed in Lagos #EndSARS crises. *Vanguard*.

Yomi, K. (2020, October 13). How a youth-led degital movement is driving Nigerias largest protests in a decade. *Quartz Africa*.

Performance Analysis of Railway Transportation Services on Abuja – Kaduna Route, Nigeria

O'odoh, B. A.[1a], Owoeye, I. O[2], Busari, A. O.[1b], Shehu, M.[1c], Haruna, A. M.[1d], & Hassan, H. S.[1e]
[1]Department of Civil Engineering, Federal University of Technology, Minna, Nigeria
[2]Department of Urban and Regional Planning, Federal University of Technology, Minna, Nigeria
Corresponding author email: oab.evan@gmail.com, +2349039290216

Abstract:
Increasing cost of construction, maintenance and limited capacity of road due to its sole dependence in the country has led to shift to other alternatives and has led to a renewed interest in railway transportation whose performance has dwindled over the years majorly due to neglect and mismanagement. This has necessitated the analysis of the service performance of the recently built Abuja – Kaduna rail line in view to determine its line capacity and bottlenecks. In this study, Capacity is defined as a rail line section's ability to serve a specific volume and mix of traffic while meeting service performance criteria for each type of traffic as determined by the interdependencies between the rail's infrastructural and operational parameters. As a result, a thorough examination of these factors that influence the line capacity is carried out on the Abuja – Kaduna railway. The findings indicate how line capacity is influenced by parameters including train speed, number of stations, signalling method and timetable reliability. Also, recommendations on how best to utilize the rail infrastructure to maximise capacity and improve efficiency was made.

***Keywords**: Capacity, Infrastructure, Operation, Performance, Railway*

Introduction

It is impossible to overstate the importance of transportation as the foundation of all human activity and hence an intrinsic aspect of all socio-economic relationships. The availability of a dependable and efficient mode of transportation for its population is critical to any economy's and region's development. Ademiluyi (2006) observed that Nigeria is a country with a high level of human spatial mobility. As a result of this population characteristic, there is a strong demand for public transportation. This goes on to add that, because of its ability to increase the productivity of human and material resources, an efficient, safe, and dynamic transportation infrastructure is critical to a nation's long-term social, economic growth, and development.

The railway system, among all other modes of transportation, plays a key part in the advancement and development of any economy (Adesanya, 2010). This is due to the fact that it has a clear advantage over other means of land transportation in the movement of goods and people. It provides access to rural areas, regions, and the hinterland, attracting commercial, educational, and residential settlements and development along its corridor, easing pressure on poorly maintained and congested highways, and allowing for the transport of large quantities of goods and passengers (Adesanya, 2002; Enebeli-Uzor, 2012). Its capabilities, which is further enhanced by its safety and security features, as well as its ability to travel larger distances with ease and lower unit costs, puts it in a strong position to serve as a nation's transportation hub (Nwanze, 2002). Hensher (2007) regarded rail transportation as one of the most potent single initiators of economic take-off in history, as a major factor in market expansion and a prerequisite for growing the export sector.

The objective of this paper is to determine the line capacity of Abuja – Kaduna Rail line. Line capacity being defined as the maximum number of trains that can be operated over a section of track in a given period of time, typically one hour (Transportation Research Board, 2003). UIC (2004) opposed the notion that capacity exists in railway and railways infrastructure capacity depends on the way it is utilised and based on interdependencies existing between the number of trains, the average speed, the stability and the heterogeneity. There are several ways for calculating capacity utilisation, which is defined as "the amount of capacity used for a particular timetable on a given infrastructure" (Landex, 2008). They can be classified into four groups, according to Krueger (1999) and Abril et al. (2008): Analytical methods, such as graphical compression methods, parametric models, such as those proposed by Krueger (1999) and Lai (2008), optimization, such as that proposed by Lusby *et al.* (2009), and simulation, such as the RailSys software.

Analytical approaches quantify railway capacity use using simple mathematical calculations or timetable compression methods. These methods provide a rapid and easy overview of a route or network, but they cannot account for the complicated structure of railway capacity.

To describe and analyse capacity utilisation, parametric models incorporate some factors of railway infrastructure and operation. Prokopy and Rubin (1975) created the first parametric model for calculating used capacity using train delay as a function of physical, operational, and control parameters (Lai and Barkan, 2009b). Krueger (1999) created another parametric model for the Canadian National Railway.

Mathematical programming and operations research are not directly used for modelling and optimising capacity utilisation (that is; maximising efficient capacity utilisation, subject to demand/infrastructure/ signalling/ operational/ rolling stock/ fare/ access charge constraints) due to the very complex and multidisciplinary nature of railway capacity. As a result, optimisation approaches are mostly used to capacity utilization subproblems such as train scheduling, rescheduling, and routing, as well as track and platform allocation. Hansen *et al.* (2008) contains chapters on timetable design concepts, infrastructure modelling, Time Table stability analysis, optimisation models for railway timetabling, simulation, rescheduling, and performance evaluation. A current survey on track allocation models and approaches is presented by Lusby *et al*. (2009).

Simulation can be used in two ways to analyse railway capacity utilisation: as a tool in conjunction with other methodologies such as improving timetables by simulating train scheduling and rescheduling, or as a software package with some direct or indirect features for capacity analysis. Barber *et al.* (2007) and Kontaxi and Ricci (2007) give a detailed survey of railway simulation software.

Methodology

Study Area

The Abuja – Kaduna rail Line is a 186KM standard gauge rail line. Also, a single-track rail with 9 intermediate stations from Abuja (Idu) – Kaduna (Rigasa) amongst which 5 are Passenger/intermediate stations and 4 non-stopping/passing stations.

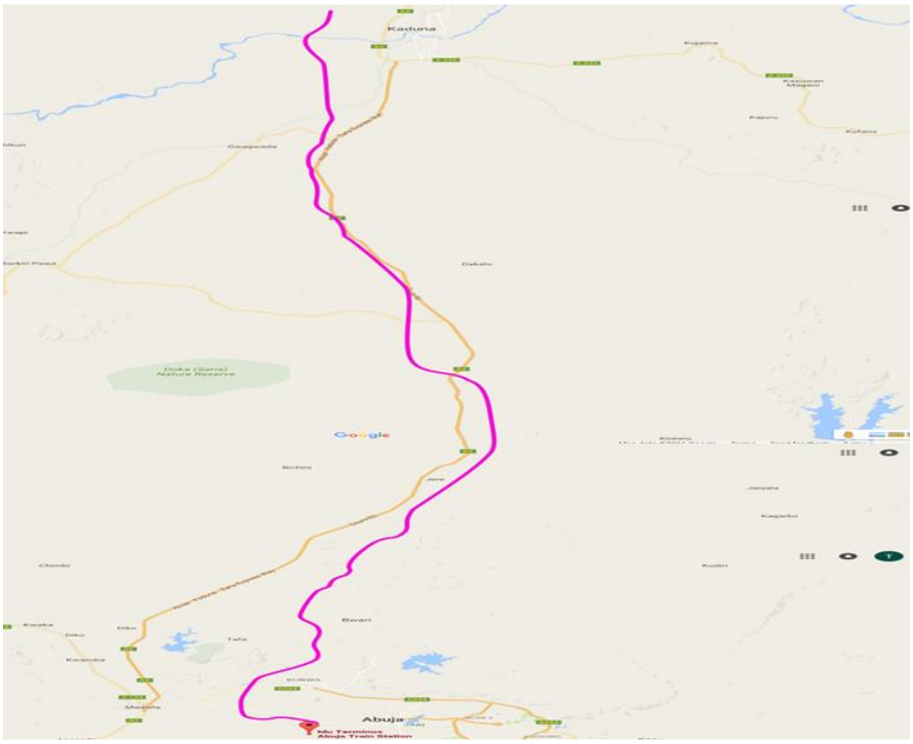


Figure 1: Route Map using Google

Line Capacity Analysis

To determine the Line capacity of the railway, the Transit Capacity and Quality of Service Manual, mathematical method which takes into consideration infrastructural and operational parameters, was used to generate a spreadsheet that was able to calculate the capacity. The procedure is as below: (Transportation Research Board, 2003b).

Step l: Determine the Control System's Minimum Train Separation (Fixed Block)

$$t_{cs} = \sqrt{\frac{2(L_t + d_{eb})}{a}} + \frac{L_t}{V_a} + \left(\frac{1}{f_{br}} + b\right)\left(\frac{v_a}{2d}\right) + \frac{at_{os}^2}{2v_a}\left(1 - \frac{v_a}{v_{max}}\right) + t_{os} + t_{jl} + t_{br}$$

GENERAL PARAMETERS	
L_t	Longest train length (m)
d_{eb}	Distance from front of stopped train to start of exit block (m)
v_{max}	Maximum line speed (km/h)
v_a	Station approach speed (km/h)
f_{br}	Braking safety factor (percent service braking rate)
t_{os}	Overspeed governor operating time (automatic system) or driver sighting and reaction time (manual system) (s)
t_{jl}	Time lost to braking jerk limitation (s)
t_{br}	Brake system reaction time (s)
a	Initial service acceleration rate (m/s^2)
d	Service deceleration rate (m/s^2)
a_g	Acceleration due to gravity (m/s^2)
G_i	Percent grade into station (%)
G_o	Percent grade out of station (%)
l_v	Percent of specification line voltage (%)
PARAMETERS SPECIFIC TO THE CONTROL SYSTEM	
b	Three-aspect separation safety factor
b	Cab separation safety factor
b	Moving block separation safety factor
P_e	Positioning error (moving block only) (m)
S_{mb}	Safety distance (moving block only) (m)
Calculations	
t_{cs}	Minimum train control separation - fixed-block or cab signals (s)

Step 2: Determine the average dwell time at the critical station

Step 3: Select an operating Margin

Step 4: Determine the minimum headway associated with the Right-of-way Type

Step 5: Determine the Controlling Headway: This is the sum of minimum train separation time (Step 1), average dwell time at the critical station

(Step 2), and the operating margin.

Step 6: Determine the Train Throughput.

Result and Discussion

Investigations were conducted on the rail gauge, track, stations and signalling system which falls under infrastructural capacity factors. Also, rolling stock speed, door mechanism, number of coaches; heterogeneity, stability & reliability of timetable which falls under operational capacity factors. The both factors were utilised in the calculation of the Line capacity. Table 1. stipulates some of the main technical features of the Abuja – Kaduna rail line such as the width of the gauge which has an impact on the capacity of the railway because the wider the gauge the higher the speed and carry capacity, ruling grade, design speed and in general, other main technical standards.

***Table 1:** Summary of Main Technical Standard*

Items	Measurement
Gauge	1,435mm
Ruling (max.) Grade	12%
Speed Target Value	150km/h
Minimum Radius of Curve	2,000m for ordinary conditions 1,600m for difficult conditions 1,200m for individual conditions
Type of Traction	Diesel
Traction Tonnage	20.00t
Effective Length of Arrival and Departure Track	850m
Signaling	Automatic Inter-station Block Signaling

The Abuja – Kaduna rail line is designed for a speed of 150km/h, a maximum speed of 100km/h is used in operations. The speed at which trains can go on tracks is a critical element in determining how much railway capacity is used. The faster the trains go, the less time the infrastructure is used and the more people and products can be delivered. Due to infrastructure constraints, such as line speed, trains are rarely able to run at full speed.

The Abuja – Kaduna rail line is a single-track railway and its theoretical capacity is heavily influenced by the number of tracks. Trains travelling in opposite directions collide on single-track lines, significantly increasing the allotted waiting time. The theoretical capacity on introducing a double track line is often quadrupled, according to estimates (Nash, 1982).

The number of trains that can safely move across a railway determines capacity utilization. Railways have an average coefficient of adhesion of eight times less than road transportation, which requires considerable braking distances (Pachl, 2008). The Abuja – Kaduna railway uses automatic inter-station block signal which is a sort of fixed block signal in the traditional sense. A train can only move from one station to another so far as no other train is on that section of the rail and in order to increase capacity several stations need to be built and this puts a strain on capital and resources. This affects the Abuja – Kaduna rail greatly and constrains capacity.

***Table 2:** Calculation of line capacity*

Step 1: Determine the Control System's Minimum Train Separation Variables		
	Type of control system	Three-aspect
	Type of moving-block signalling system safety separation	
Inputs		**1**
GENERAL PARAMETERS		
L_t	Longest train length (m)	320
d_{eb}	Distance from front of stopped train to start of exit block (m)	325
v_{max}	Maximum line speed (km/h)	100
v_a	Station approach speed (km/h)	100
f_{br}	Braking safety factor (percent service braking rate)	75%
t_{os}	Overspeed governor operating time (automatic system) or driver sighting and reaction time (manual system) (s)	3.0
t_{jl}	Time lost to braking jerk limitation (s)	0.5
t_{br}	Brake system reaction time (s)	1.5
a	Initial service acceleration rate (m/s^2)	0.3
d	Service deceleration rate (m/s^2)	0.3
a_g	Acceleration due to gravity (m/s^2)	10
G_i	Percent grade into station (%)	0%
G_o	Percent grade out of station (%)	0%
l_v	Percent of specification line voltage (%)	
PARAMETERS SPECIFIC TO THE CONTROL SYSTEM		
b	Three-aspect separation safety factor	2.4
b	Cab separation safety factor	1.2

b	Moving block separation safety factor	1.0
P_e	Positioning error (moving block only) (m)	20.5
S_{mb}	Safety distance (moving block only) (m)	165
Calculations		
t_{cs}	Minimum train control separation - fixed-block or cab signals (s)	987.4
t_{cs}	Minimum train control separation - moving block FSD (s)	332.0
t_{cs}	Minimum train control separation - moving block VSD (s)	579.0
Output		
t_{cs}	***Minimum train control separation (s)***	***987.4***

Step 2: Average Dwell Time at critical station is 300 seconds.

Step 3: Operating Margin of 25 seconds.

Step 4: Determine the Minimum Headway Associated with the Right-of-Way Type		
Default Values		
	Type of right-of-way	Single-track
Inputs		**1**
L_{st}	Length of single-track section (m)	21
N_{st}	Number of stations on single-track section	1
v_{max}	Maximum speed reached in single-track section (mi/h)	100
t_d	Average station dwell time in single-track section (s)	300
S_m	Speed margin	1.10
t_s	Switch throw and lock time (s)	8
t_{om}	Operating margin for single-track section (s)	25
Calculations		
t_{st}	Time to cover single-track section (s)	1955
Output		
h_{st}	***Minimum single-track headway (s)***	***3910***
h_{row}	***Minimum headway associated with ROW type (s)***	***3910***
Step 5: Determine the Controlling Headway		
Import Data		
	Import data from Steps 1 - 3 (optional)?	No
Inputs		**1**
t_{cs}	Minimum Train Separation Time	987
	Average Dwell Time at Critical Station	300
	Train Operating Margin	25
Output		
h	***Controlling headway (s)***	1312
Step 6: Determine Train Throughput		
Inputs		
h	Controlling headway (s)	1312
Output		
T	***Line capacity (trains/h)***	***2***

From the result computed in Table 2, the railway has a line capacity of 2 trains per hour. This at the moment despite being poor is not an issue since all the demands for the rail service presently are almost being met. That is to say that the impact on railway capacity utilization is influenced heavily by the demand of the service which in turn influences the timetable of the trains. Currently the demand is yet to put a strain on the rail infrastructure. But in future, Abuja – Kaduna railway being just a segment of the proposed Lagos – Kano rail line and as such when the whole line is completed will lead to an increase in demand and in traffic which will demand scaling up of the capacity along the line. This can be done by improvement of signalling method and dualization of tracks or adding of more sidings.

Conclusion

The growth in train passenger volume exceeds the expansion of railway track capacity on the supply side. As a result, numerous railways around the world are experiencing capacity constraints. Abuja – Kaduna railway if not now will experience such issues in the nearest future. In this case, it is critical to accurately measure and control capacity utilization.

This study determined the line capacity of Abuja – Kaduna railway to have a throughput of 2 trains per hour. This result presently satisfies the demand for the rail service but is also poor. Various factors both infrastructural and operational points to signalling, number of tracks as the major infrastructural factor constraint of capacity along the rail line while train timetable as the operational factor constraint.

References

Abril, M., Barber, F., Ingolotti, L., Salido, M. A., Tormos, P. &Lova, A. 2008. An assessment of railway capacity. *Transportation Research Part E: Logistics and Transportation Review,* 44**,** 774-806.

Ademiluyi, I. A. (2006) Rail transport system in Nigeria: Its contributions, constraints and the way forward. Knowledge Review, 12(4), 1-8.

Adesanya, A. (2002). "Reviving the Nigerian Railways" Text of a Lecture Delivered at the National Training Workshop on Transport Planning and Management in a Depressed Economy, Held at NISER, Ibadan.

Adesanya, A. (2010). "Bringing the Nigerian Railways Back on Track: Challenges and Options" Text of a Lecture Delivered at the Monthly NISER Seminar Series, Held at NISER, Ibadan.

Barber, F., Abril, M., Salido, M. A., Ingolotti, L., Tormos, P. &Lova, A.2007. Survey of automated systems for railway management Valencia: Department of Computer Systems and Computation, Technical University of Valencia.

Enebeli-Uzor, S. (2012). "Rail System: Nigeria's Neglected Critical Transport Infrastructure" Zenith Econ. Quart., 8(1): 47-51.

Hensher, D.A. and Prioni, P. (2002) "A service quality index for area-wide contract performance assessment regime", Journal of Transport Economics and Policy 36 (1), pp. 93-113.

Kontaxi, E. K. & Ricci, S. 2011. Calculation of railway network capacity: comparing methodologies for lines and nodes. *4th International Seminar on Railway Operations Modelling and Analysis* Rome, Italy.

Krueger, H. Parametric modelling in rail capacity planning. 1999 winter simulation conference, 1999. 1194-2000.

Lai, Y. C. &Barkan, C. P. L. 2009b. An enhanced parametric railway capacity evaluation tool (RCET). *88th Transportation Research Board annual meeting.* Washington, USA.

Landex, A. 2008. *Methods to estimate railway capacity and passenger delays.* PhD, Technical university of Denmark.

Lusby, R., Larsen, J., Ehrgott, M. & Ryan, D. 2009. Railway track allocation: models and methods. *OR Spectrum*.

Nash, C. 1982. *Economics of public transport,* London, Longman.

Nwanze, E. (2002) Conceptualizing of the Nigerian Transport problems and the need for an integrated national transport system. A paper presented at the conference on revitalization of railway transport in Nigeria at the Centre for Transport Studies, Olabisi Onabanjo University, Ago-Iwoye, August, 2002.

Pachl, J. 2008. Timetable design principles. *In:* HANSEN, I. A. & PACHL, J. (eds.) *Railway timetable and traffic.* Hamburg: Eurailpress.

Pachl, J. 2009. *Railway Operation and Control,* Mountlake Terrace (USA), VTD RailPublishing.

Prokopy, J. C. & Rubin, R. B. 1975. Parametric Analysis of Railway Line Capacity.*DOT-FR-5014-2, Federal Railroad Association, U.S. Department of Transportation.* Washington, DC.

Transportation Research Board 2003. Rail Transit Capacity. *Transitcapacity and quality of service manual.* Washington, US.

An Investigation into the Satisfaction Level of Student Accommodation in Students' Living Environment of Modibbo Adama University of Technology, Yola, Nigeria

Ekule, A. A.[1]; Abdul, C. I.[1,2]; Idachaba, M. K.[1] & Nuhu, A. A.[1]

ekuleadejoh@yahoo.com; ileanwa@graduate.utm.my; kidachaba@yahoo.co.uk; arcnuhu@gmail.com

[1]*Department of Architectural Technology, School of Environmental Technology, Kogi State Polytechnic, Lokoja*

[2]*School of Architecture Programmes, Faculty of Built Environment and Surveying, Universiti Teknologi Malaysia, Johor, Malaysia.*

Correspondence email**:** *ekuleadejoh@yahoo.com*

Abstract

Many of the world's acute problems such as crime, poverty, pollution and destruction of the environment are linked to the unchecked growth of human species. The major problem identified as cause of dissatisfaction in the students' living environment is the occupancy ratio as compared with the population density. This research is aimed at determining the student's level of satisfaction with the physical condition of structures, facilities and utilities in the area under study. The objectives are to assess the implications of overcrowding on the physical condition of the sampled structures and its effects on satisfaction level of students with available facilities and identify its social and psychological effects on occupants. Systematic evaluation of selected occupied hostels in Modibbo Adama University of Technology, Yola, Adamawa State, North-east of Nigeria was carried out and achieved by using a quantitative research method to explore users' opinion on preferred spatial needs, level of satisfaction, space organization and preferred numbers of users to share facilities. Data were obtained through primary and secondary sources. The frame work of the study was expanded to address physical and social variables. Stratified sampling technique to get male and female participants and systematic sampling to get participant from selected rooms at an interval calculated from 15% of 1008 male and 30% of 448 female population in the hostels. Physical congestion, overburdened physical, social and public facilities, utilities and services affect the structures. It is recommended that adequate accommodation for students be provided, strict adherence to standard in the number of occupants per dwelling unit be adhered to and elimination of squatters and illegal occupants be adopted.

Keywords: Facilities, Living environment, Overcrowding, Satisfaction, Students.

Introduction

The word "density" refers to the physical conditions created by varying quantities of space and populations of people; when density rises, a person may encounter more people or fewer spaces accessible for their usage (Baum and Koman, 1976).With an increase in students due to an increase in interest in tertiary institutions of learning over time, student housing has become a major issue of concern. The burden on the academic and residential facilities of Nigeria's public institutions has increased as a result of the desire of many students to continue their education there. The study is aimed to determine the student's level of satisfaction with the physical condition of structures, facilities and utilities in the study area, the effects of overcrowding on the dissatisfaction of students with these factors through obtaining users' level of satisfaction with hostel space and facilities and the most preferred number of users to share space and facilities. It is essential for schools to prioritize student housing while boosting the school's reputation among its peers because student housing is one of the amenities that students examine before choosing the school they wish to attend, among other factors (Toyin Sawyerr and Yusof, 2013).

It is crucial for student housing to offer the basic infrastructure facilities needed by the student, such as toilets, water supply, electricity, reading rooms, canteens, butteries, kitchens or kitchenettes, and recreation areas. The provision of these facilities in good working order is typically not always readily available (Adedeji, 2016). The university administration must take into account how well the students are treated because this has an impact on their ability to do well academically, especially when they enjoy their studies and have a comfortable lifestyle (Mansor *et al.*, 2020). In order to help housing administrators and facility managers at higher education institutions enhance their services and provide better housing facilities in the near future, we intend to analyse the residential satisfaction of students (Najib, 2011).

Housing satisfaction is influenced by a variety of individual elements, including life stages, social and cultural background, financial condition, and aspirations, as well as the architectural features of a structure or residence. By contrasting their preferences with their actual living circumstances, people gauge their level of housing satisfaction (Thomsen and Eikemo, 2010). Student affairs administrators have a special opportunity to enhance and support university students' educational experiences through student living facilities (Navarez, 2017).

The availability of top-notch student housing facilities is anticipated to serve as an efficient recruitment tool for local and foreign students to Malaysian universities, and additional efforts should be directed toward raising the index's score on the student residential satisfaction scale ('Ulyani Mohd Najib *et al.*, 2011). The basis for making decisions about improvements to the current housing stock and the design and development of future housing is the evaluation of student housing facilities. Additionally, the possibility of conducting a performance evaluation of housing increases the accountability of housing managers, designers, and policy makers (Amole, 2009).

Research Methods

The research was carried out using a case study research design method. The information needed for the effective execution of this research work were derived from the assessment of sampled university student hostels of the study area, direct physical observations and the administration of questionnaire in the studied student housing to get response from personal opinion of the residents in the student halls of residence.

Stratified random sampling was also used to get a sample from two different groups with respect to gender difference (male and female) and Systematic sampling technique as explained by Jen (2007) to get samples of residents from each previously sampled hall of residence in the study area. 15% of the total population of each hostel was sampled which is 5% higher than the minimum of 10% population as explained by Jen (2007) for more accuracy. The sampled buildings were: Kabir Umar Male Hostel and Chukwu Female Hostel.

Previous Studies

According to the study on assessment of the state of the facilities in the student residence halls at Obafemi Awolowo University by Adedeji (2016), more than the average number of facilities at the University are in deteriorating condition. The findings revealed that 54% strongly agreed that the water closet is bad, 54.4% and 38.9% strongly agreed that the bathroom and water closet were both bad, 39.3% strongly agreed that the window/door was bad, 22.6% strongly agreed that the electric appliance was bad, and 64.6%. The study concluded that student's lives will be endangered if the facilities are not fixed in their proper condition to serve the students. In order to ascertain the degree of students' satisfaction with the conditions of the facilities and the dormitories in Federal Universities in North Central Nigeria, satisfaction evaluations were carried out by Philip *et al.*, (2018). According to the findings, 91.7% of the students were dissatisfied with their hostel accommodations, whereas 8.3% of the respondents were satisfied. The study came to the conclusion that the bad condition of the hostel facilities would rather make a hostel look like a shelter and would adversely influence the quality of education and the student's psychology toward differentiating between standard and ordinary facilities in a larger community.

In a study to determine the impact of space design on occupants' contentment with indoor environment in university dorms, Dong *et al.*, (2022) examined five types of spaces to determine the most satisfying space type, and discovered that single and double rooms with balconies offered more satisfaction. The area per capita increased along with the pleasure of the tenants, although the growth was only moderate after the value reached 13.5 m2. The study added a fresh perspective to the field of indoor environmental quality research by demonstrating the significance of space design on occupant happiness, which warrants further study.

In Bangladesh's public universities, Rahman *et al.*, (2020) conducted a study to determine the key service parameters that affect students' satisfaction. The study concluded that the number of hostels was insufficient to meet the demand of the students, leading to their dissatisfaction with various services provided by the hostel authority as well as the absence of other services surrounding their hostels, and found a negative correlation between housing facilities and students' satisfaction, indicating that students are not satisfied with the housing facilities provided by the public universities. Using structured questionnaires to gather the data, a case study was conducted to assess the post-occupancy state of university residences at Southeast University of China (Ning and Chen, 2016). The findings demonstrated that university housing has top-notch physical amenities. They did not, however, deliver satisfactory services or a supportive infrastructure. This shows that while "software" is still less capable than "hardware," it may generally suit students' needs. Additionally, it has been discovered that the socio-technical systems approach has the quality of being integrated into the social, governmental, and geographical settings.

In a study conducted at University Utara Malaysia, Mansor *et al.*, (2020) found that there were differences in the degree to which undergraduate students were satisfied with the university's given housing amenities, as measured by the Relative Satisfaction Index (RSI). While the students were satisfied with the table and chairs, wardrobe, living area, and electricity in the room, they were dissatisfied with the washing machine, internet connection, shower accessories, sink, and toilet cleanliness. According to the study, a hostel's comfortable environment can have an impact on a student's academic performance.

According to a study by Osei - Poku *et al.*, (2020) to check students' satisfaction with their residences from the perspective of physical features, social amenities, and management factors, and considering purpose made halls and a converted halls, he revealed that individual Relative Satisfaction Index values indicate that students in the purpose-built hall are more satisfied with their accommodations while residents from the converted halls are more satisfied with their living arrangements,

Adegoke *et al.* (2021) in a study on the post occupancy evaluation of students hostels of Obafemi Awolowo University Ile-Ife using questionnaire and descriptive statistical tools found out that both sexes (male and female students) were generally content with social, indoor environmental quality (IEQ), and physical characteristics. However, while female students were also generally content with the supporting service, male students were generally unsatisfied. Additionally, IEQ and supportive services had an impact on both genders' levels of satisfaction.

In order to condense the data set and identify the connections between different aspects of students' contentment with their off-campus living, Muslim *et al.*, (2013) used the factor analysis approach. Results from a descriptive analysis indicate a level of satisfaction with each home environment level (house, neighborhood and city). This study reveals the large differences that exists between campus accommodation and off campus accommodation in universities.

Results and Discussion

This is in three main parts, the discussion on response to the questionnaire with questions relating to implications of the effects of overcrowding on students' satisfaction, the case studies and an application of the findings of the research finding. Equally the results are presented and discussed in accordance to the research questions to provide answers.

Presentation of Result

Research question 1: -What is the level of satisfaction with the hostel space and facilities?

The distribution in Table 1 presents level of satisfaction with each facility spaces under the variables from the response of hostel users classified under the male and female starters consisting of 110 male respondent and 120 female respondents. The five Likert ordinal scale satisfaction was used; strongly satisfied, satisfied, fairly satisfied, unsatisfied and strongly satisfied.

Table 1: Students satisfaction with hostel facilities

S/N	VARIABLES								
				SS=Strongly satisfied, S=Satisfied, FS= Fairly satisfied, US= Unsatisfied, SUN=Strongly unsatisfied				Remark	
1.	**Satisfaction Level with Study Bedroom**			Frequency Of Response		% of Response			
				M	F	M	F	M	F
	Size of the Study bedroom		SS	20	20	18.18	16.67	Satisfied	Fairly Satisfied
			S	45	25	40.91	20.83		
			FS	25	40	22.73	33.33		
			US	15	30	13.64	25		
			SUN	5	5	4.55	4.17		
			Total	110	120	100	100		
	Privacy in Study Bedroom		SS	20	15	18.18	12.5	Fairly Satisfied	Unsatisfied
			S	15	10	13.64	8.33		
			FS	45	25	40.91	20.83		
			US	15	50	13.64	41.67		
			SUN	15	20	13.64	16.67		
			Total	110	120	100	100		
	Number of persons in study bedroom		SS	18	15	16.36	12.5	Unsatis-fied	Strongly Unsatisfied
			S	10	15	9.09	12.5		
			FS	25	20	22.73	16.67		
			US	52	25	47.27	20.83		
			SUN	5	45	4.55	37.5		
			Total	110	120	100	100		
2.	**Satisfaction Level with Washroom Facilities**								
	Number of People Sharing the Bathroom		SS	15	15	13.64	12.5	Fairly Satisfied	Strongly Unsatisfied
			S	30	15	27.27	12.5		
			FS	40	20	36.36	16.67		
			US	10	25	9.09	20.83		
			SUN	15	45	13.64	37.5		
			Total	110	120	100	100		
	Size of Bathroom		SS	15	0	13.64	0	Strongly unsatisfied	
			S	15	15	13.64	12.5	Unsatisfied	
			FS	20	23	18.18	19.17		
			US	25	45	22.73	37.5		
			SUN	35	37	31.82	30.83		
			Total	110	120	100	100		

a. Satisfaction level with study-bedroom: Majority of the male with percentage response of 40.91% was satisfied and female with percentage response of 33.33 % was fairly satisfied with the size of the study-bedroom. Majority of the male with percentage response of 40.91% was fairly satisfied and female with percentage response of 41.67 % was unsatisfied with the privacy in the study-bedroom. Majority of the male with percentage response of 47.27% was unsatisfied and female with percentage response of 37.5 % was strongly unsatisfied with the number of persons in the study-bedroom.

b. Satisfaction level with washroom facilities: Majority of the male with percentage response of 36.36% was fairly satisfied and female with percentage response of 37.5% were strongly unsatisfied with the number users sharing the bathroom. Majority of the male with percentage response of 31.82%

was strongly unsatisfied and female with percentage response of 37.5% was unsatisfied with the size of the bathroom.

c. Satisfaction level with laundry facilities: Majority of the male with percentage response of 40.91% was satisfied and female with percentage response of 44.17% were unsatisfied with the size of the laundry space. Majority of the male with percentage response of 41.82% were satisfied and female with percentage response of 39.17% were satisfied with the cleanliness of the laundry space. Majority of the male with percentage response of 46.36% were fairly satisfied and female with percentage response of 42.5% were fairly satisfied with the number of persons sharing the laundry space.

Research question 2: What is the most preferred number of users to share space and facilities?

Majority of the male with percentage response of 67.27% prefer 3-4 students per each hostel room and majority of female with percentage response of 52.50 % suggested that a room in the hostel should contain 2 students maximum. None of the respondents indicated more than 7 students per hostel room.

Table 2: Preferred Number of Users per room.

Number of students in room hostel	Frequency		Percent		Cumulative Percent	
	M	F	M	F	M	F
2 students per room	34	63	30.91	52.5	30.91	52.5
3-4 students per room	74	52	67.27	43.33	98.18	95.83
5-6 students per room	2	5	1.82	4.17	100.0	100
7-8 students per room	-	-	-	-	-	-
More than 8 students per room	-	-	-	-	-	-
Total	110	120	100.0	100		

Research question 3: Does overcrowding have any negative effect on the physical condition of the structures in the study area that contributed to dissatisfaction?

From the respondent's responses on the status of the hostels and what was seen physically during the field work, it was clear that the hostels were not in good condition as at the time of visit. Majority of the male respondents with the highest frequency of 50% described the hostels condition as unsatisfactory while majority of the female respondents with the frequency of 52.5% described it as strongly unsatisfactory. All the categories of the five Likert ordinal scale used accepted that the physical nature of structures and facilities are affected by overcrowding.

Table 3: The Status of the Hostel

Status of the hostel	Frequency		Percent (%)		Cumulative Percent (%)	
	M	F	M	F	M	F
Strongly Satisfied	2	-	1.81	-	1..81	-
Satisfied	7	3	6.36	2.5	8.17	2.5
Fairly satisfied	10	5	9.09	4.17	17.26	6.67
Unsatisfied	55	49	50	40.83	67.26	47.5
Strongly unsatisfied	36	63	32.72	52.5	100	100
Total	110	120	100.0	100		

Conclusion

Providing adequate space for education is not simply a matter of ensuring certain number of square metres of hostel accommodation for students. The study concludes on the followings;

A. Number of students that occupies a space in the hostel affects the academic performance of the students. Several vices are found on the campus and when a negative character is paired with too many students in a space, this causes emotional and psychological disturbances to the other roommates.

B. Fewer number of students per room enhances the academic performance of students. The more conducive an environment is, the better it is for the students to perform well academically.

C. Periodic checks are not being conducted to checkmate the number of students in hostels compared to the spaces provided for student's accommodation. Most universities are allowed to admit students beyond the university carrying capacity and this in turn affects the accommodation problems faced by the institution and students in particular.

D. Accommodation problems are not particular to Modibbo Adamawa University alone. Most universities in Africa and some Asian countries encounter the same challenges as reviewed from the study.

E. Off campus accommodation presently selling and expanding around university campuses are as a result of some comfort the students find there that are not available on campus accommodations which mostly are space related as fewer or single students live in a room on off campus accommodation for adequate convenience and comfort.

Recommendations

1. The present practice of admitting students before the issue of accommodation is considered should be stopped and a new system of attaching available accommodation to the admission process should be practiced so that only the students who can be accommodated will be admitted.

2. Public private partnership should be embraced to allow developers to build hostels on campuses and manage them for agreed period of time before they are transferred to the school management.

3. Minimizing the level of room occupancy by the establishment of maintenance and monitoring unit saddled with the responsibility of controlling the number of students per dwelling unit and periodical renovation of the hostels.

4. Adherence to standard in the number of people per dwelling unit and elimination of squatters/illegal occupants in the students' hostels.

5. There should be provision of adequate social amenities on campuses especially close to hostels to help the students in the relief of academic stress which in turn refreshes the students and also enhances their academic performances.

REFERENCES

'Ulyani Mohd Najib, N., Aini Yusof, N. and Zainul Abidin, N. (2011) 'Student residential satisfaction in research universities', *Journal of Facilities Management*, 9(3), pp. 200–212.

Adedeji, I.- (2016) 'Causes and Effect of Deterioration in Students' Hall of Resident in Nigeria Tertiary Institution', *IOSR Journal of Humanities and Social Science*, 21(08), pp. 65–73.

Adegoke, A. S., Ajayi, C. A., Oladokun, T. T. and Ayodele, T. O. (2021) 'A post-occupancy evaluation of students' halls of residence in Obafemi Awolowo University, Ile-Ife, Nigeria', *Property Management*, 39(2), pp. 163–179.

Ainon, R. and Rosmaizura, M. Z. (2018) 'The impact of facilities on student choice', *Sci.Int.(Lahore)*, 30(2), pp. 299–311.

Ajayi, M. (2015) 'Students ' Satisfaction With Hostel Facilities in Federal University of', *European Scientific Journal ESJ*, 11(34), pp. 402–415.

Amole, D. (2009) 'Residential satisfaction in students' housing', *Journal of Environmental Psychology*, 29(1), pp. 76–85.

Baum, A. and Koman, S. (1976) 'Differential response to anticipated crowding: Psychological effects of social and spatial density', *Journal of Personality and Social Psychology*, 34(3), pp. 526–536.

Dong, Z., Zhao, K., Ren, M., Ge, J. and Chan, I. Y. S. (2022) 'The impact of space design on occupants' satisfaction with indoor environment in university dormitories', *Building and Environment*. Elsevier Ltd, 218(April), p. 109143.

Mansor, R., Zaini, B. J., Sarkawi, M. N. and Phay, L. E. (2020) 'Relative Satisfaction Index on Students' Satisfaction towards Hostel Facilities', *Test Engineering and Management*, 2(10757), pp. 10757–10765.

Muslim, M. H., Karim, H. A., Abdullah, I. C. and Ahmad, P. (2013) 'Students' Perception of Residential Satisfaction in the Level of Off-Campus Environment', *Procedia - Social and Behavioral Sciences*. Elsevier B.V., 105, pp. 684–696.

Najib (2011) 'Measuring Satisfaction with Student Housing Facilities', *American Journal of Engineering and Applied Sciences*, 4(1), pp. 52–60.

Navarez, J. C. (2017) 'Student Residential Satisfaction in an On-Campus Housing Facility Presented at the DLSU Research Congress 2017', *De La Salle University*, 1(2008), pp. 1–11.

Ning, Y. and Chen, J. (2016) 'Improving residential satisfaction of university dormitories through post-occupancy evaluation in China: A socio-technical system approach', *Sustainability (Switzerland)*, 8(10).

Osei - Poku, G., Braimah, A. and Clegg, R. (2020) 'Comparative assessment of user-satisfaction with on-campus residential accommodation at Takoradi Technical University, Ghana', *Journal of Building Performance*, 11(1), pp. 1–12.

Philip, A., Ileanwa, A. C. and El-Hussain, A. M. (2018) 'Post-Occupancy Evaluation of Students Hostel Facilities in Federal Universities in North Central, Nigeria', *Architecture Research*, 8(4), pp. 123–128.

Rahman, S. M. M., Mia, M. S., Ahmed, F., Thongrak, S. and Kiatpathomchai, S. (2020) 'Assessing students' satisfaction in Public Universities in Bangladesh: An empirical study', *Journal of Asian Finance, Economics and Business*, 7(8), pp. 323–332.

Simpeh, F. and Adisa, S. (2021) 'Evaluation of on-campus student housing facilities security and safety performance', *Facilities*, 39(7–8), pp. 470–487.

Simpeh, F. and Shakantu, W. (2020) 'An on-campus university student accommodation model', *Journal of Facilities Management*, 18(3), pp. 213–229.

Thomsen, J. and Eikemo, T. A. (2010) 'Aspects of student housing satisfaction: A quantitative study', *Journal of Housing and the Built Environment*, 25(3), pp. 273–293.

Toyin Sawyerr, P. and Yusof, N. A. (2013) 'Student satisfaction with hostel facilities in Nigerian polytechnics', *Journal of Facilities Management*, 11(4), pp. 306–322.

Bus Stop Location Considering Passengers Waiting Time and Cost

Ojidoh, C.[1a], Mohammed S.[1b] and Hawawu A.[1c]
[1]*The Department of Civil Engineering, Federal University of Technology, Minna, Niger State Nigeria*
[a]Chieduojidoh@hotmail.com; [b]M.Shehu@futminna.edu.ng,
Corresponding E-mail: Chieduojidoh@hotmail.com; (+234 805 700 6466)

Abstract:

Bus stops help to make public transportation accessible; nevertheless, if they are not correctly placed, they have a detrimental impact on mobility. The position of the bus stations is a balance between commuter access and mobility. This paper addresses the development of a preferred route as well as the positioning of Bus Stops along the Federal University of Technology Minna, Gidan Kwano to Bosso Campus corridor, taking into account passenger waiting time and cost. To optimise the survey, only the most frequently used routes by commuters were identified, and a single corridor was chosen for investigation based on the road corridor's features and the availability of prospective trip generators for the school bus transit system. A complete inventory survey was used to obtain possible route data for route mapping. This was then analysed with a route optimisation tool to determine the shortest and most efficient path to minimise the running cost for the vehicle/bus operators. Roadside interviews were undertaken to establish passenger behaviours and trends in order to determine passenger characteristics. According to the survey results, the majority of passengers favour cheaper modes of transportation, which happen to be buses. Passengers spent an average of 25 to 40 minutes at bus stops along the chosen route. Following data analysis, the research will strive to restrict the total number and placement of bus stops to decrease passenger waiting time.

Keywords: *Transportation, Commuters, Bus Stop, Waiting Time.*

Introduction

Transportation is the movement of humans, animals, and goods from one location to another (Drezner and Hamacher, 2002). Public transport plays a key role in urban mobility because it aims to meet the needs of citizens for ease of movement (Alkheder, et al, 2016). The larger the urban centre, the more complex it is for movement and increases the necessity for an efficient public transportation system.

The bus stop is the first point of contact between the passenger and the bus service (Murray, 2010). To improve the quality of bus services bus stop is recognized as a crucial element. Accessibility of a bus stop is a critical element that will determine the use of public transport (García, et al, 2012) and the location of bus stops significantly influence bus transit system performance and customer satisfaction. The choice of location is primarily related to the operational performance of the bus route and traffic, but can also be influenced by the adjacent land uses and opportunities for easy transfer to crossing bus routes (García, et al, 2012).

However, the unplanned location of bus stops leads to low public bus service quality, for example, the redundant distribution of bus stops within short distances in most central areas increases unnecessary bus stopping and passenger waiting time (Murray A, 2010). Furthermore, when bus stops inadequacies exist within cities and sub-urban areas, it results in low walking accessibility, satisfying less public, transportation demands, and also causing social inequity (Bohannon & Andrews, 2011). This is the situation that is being witnessed along the route of FUTMinna and its planned campuses. The performance of a transit system can be significantly improved if the spacing of bus stops is optimized (Chen and Chien, 2001), where the location of the bus stops is not planned as in the case of the FUTMinna road corridor, they only exist naturally, these are inadequate as the commuters stop at any point along the route and wave to ride, this results in delays and disturbance of the traffic flow within the urban cities of Minna.

The capacity of a location to be reached from or by other locations is measured by its accessibility. As a result, the capacity and layout of transportation infrastructure are critical factors in determining accessibility. Accessibility is an important factor in transport geography and general geography because it is a direct expression of mobility, whether in terms of people, freight, or information.

Alexander, et al, (2007), describe the accessibility of bus stops as affected by many factors, two of which are pivotal in increasing both the attractiveness and sustainability of public transport:

the quality of the urban environment in these facilities are located in;

the type of functions and operations associated with them, which dictate their "status", from simple bus markers to bus shelters, to transit hubs.

Statement of the Problem

The present situation of the bus transportation system along the Federal University of Technology Minna route is very sporadic and unplanned, resulting in long delays for commuters at the bus stops and inefficiency on the part of bus owners. What obtains along the corridor is the hail and ride system whereby commercial vehicles stop anywhere to allow boarding or alighting, as desirable by commuting public. A commercial vehicle driver keeps a lookout for intending passengers for the whole of the journey often resulting in delays, disrupting smooth traffic flow, and may cause accidents.

Chen & Chien (2001) describes efficient mobility as closely related to bus stop placement, noting that fewer stops generate less dwell and waiting time at stops and subsequently contribute to higher bus operating speed and efficiency. Most stops in Minna are located at nodes where commuters gather, with no signage to mark the bus stop. This lack of consistency and the often-poor bus stop infrastructure planning of location and layout impacts not only the customer's perceptions, experiences, and views of the passenger transportation network but importantly the operational effectiveness of the buses and therefore on the ability of bus operators to operate efficient and reliable services.

Purpose of the study

This make purpose of the study is to establish adequate bus stop locations for improved movement along the Gidan Kwano – Bosso Campus of the Federal University of Technology Minna, considering the passengers' waiting time and cost. Specifically, the study determined:

The best bus route and existing bus stop locations along the selected corridor.

The characteristics of commuters at existing bus stops.

Appropriate locations for the bus stops along the selected route.

Research Questions

The study was guided by the following research questions:

a) What is the best bus route for bus drivers who traverse the Federal University of Technology, Minna campuses.

What are the characteristics of commuters/passengers at existing informal bus stops.

What are the best locations for bus stops along a selected route

Literature Review

Alexander, et al, (2007), describe the accessibility of bus stops as affected by many factors, two of which are pivotal in increasing both the attractiveness and sustainability of public transport:

a) the quality of the urban environment in these facilities are located in;

the type of functions and operations associated with them, which dictate their "status", from simple bus markers to bus shelters, to transit hubs.

Adeleke & Jimoh, (2012) had done their work on bus stop locations for improved movement on an urban arterial in Ilorin Metropolis, Nigeria. They focused on the determination of optimal locations of bus stops along the corridor that will ameliorate identified problems. According to the study, the basic elements that influence bus stop demand by commuters on urban arterials include Land use, Safety, Urban Traffic Management, and walking distance between shops. The Study recommended the adoption of the standard bus stop location of 200m – 250m in the planning of urban streets in Nigeria to reflect the practices in the developed part of the world.

Fielbaum, et al, (2020) developed a multiple-period model that allows some of the optimized system characteristics (for example, route structure) to be fixed at values representing the best compromise over different periods, while other characteristics (for example, service, and headways) may be optimized within each period.

Methodology

Description of study area

Minna is situated in the north-eastern part of the area that makes up Niger state located approximately between latitudes 8°20´N and 11°30´N, and longitude 3°30´E and 7°20´E. Minna has the capital of Niger state since 1976, is located in the north-central part of the country. The town is famous for its woven and dyed cotton fabric, raffia mats and baskets, pottery, and brassware. Brick manufacturing plans and several Tertiary institutions are examples of modern industries. It is home to the Federal University of Technology, Minna campuses, as well as several other educational institutions. The city is also the shortest route from Lagos, Nigeria's commercial capital, to the Northern States. This presents a problem because heavy-duty vehicles travel through the city regularly to reach neighbouring states. These have resulted in increased activity, attracting a high volume of traffic to the chosen corridor. Due to the large number of passengers who use the corridor, there are also a large number of businesses in the area.

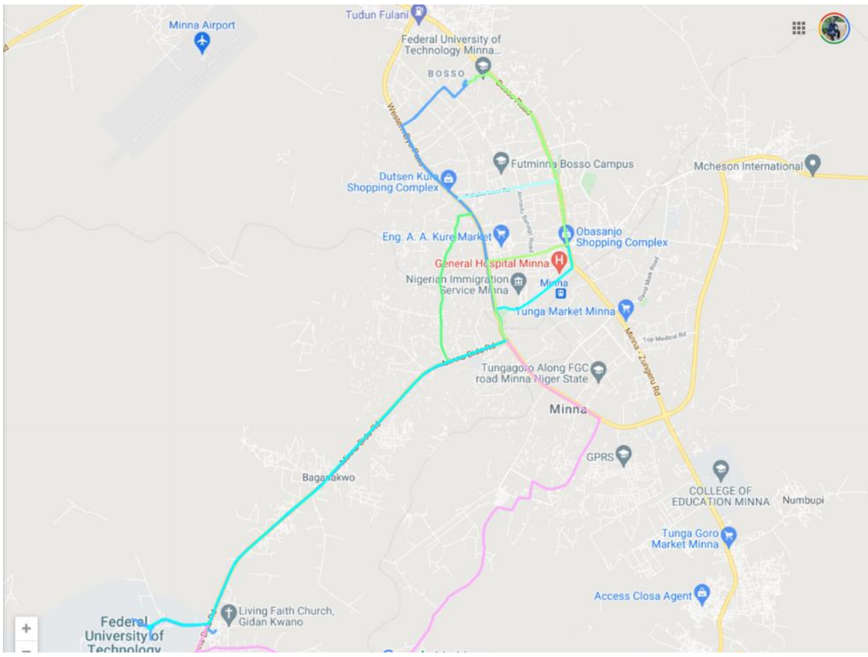


Figure 0 Aerial photograph of Minna and its environs in Niger State

Participants

A total of 887 interviews were carried out by various teams for passengers traveling between the two university campuses. Overall, to achieve adequate data capturing, three teams were deployed concurrently to capture the route characteristics and passenger behaviour through questionnaires. After analysis of the data captured from the questionnaire, an initial inventory survey was conducted to establish the distances between Stop points. The nodes and trip generator were computed for each survey, several other characteristics such as vehicle type, frequency of trip, purpose of trip, dwell time, passenger waiting time are some of the questions asked.

Data Collection and Analysis

Firstly, after the identification of the trip generator as stops/nodes, the study identified the optimal route using the Travelling Salesman shortest path problem solver with Microsoft Excel. The shortest path problem is a fundamental optimization problem with a massive range of applications. It is used in this study to selected the shortest route which in turn is the cheapest of the survey corridors for bus drivers.

The study identified multiple possible routes form the FUTMinna GK campus to the Bosso Campus. To establish the most feasible path the following parameters was considered.

There are only 3 viable routes based on the frequency of usage and the carriageway parameters. Routes in good condition and with a minimum ROW of 15m are considered appropriate to accommodate buses.

Routes were mapped from Origin at the FUTMinna GK Campus (A) to the destination at the Bosso Campus (Destination).

All nodes were labelled from origin A to Destination, with distance from A to B and to C as computed in the table 1 below:

Table.31: Sample Identified nodes along the selected routes

From	To	Distance (km)
A (origin)	B	1.57
B	C	10.10
B	N	0.50
C	D	0.78

The following criteria set by Adeleke & Jimoh, (2012); leghorn, (2020), Fernandez, (2009) will be used to determine the Transport optimum location of the bus stops along the selected corridor. These parameters will include:

The minimum standard bus stop location in Nigeria (Adeleke & Jimoh, 2012) will be a minimum distance of 250m apart. This was discussed as an optimum minimum distance for costs associated with the bus fleet, any lower will increase the cost to the bus fleet and discomfort commuters as a result of excessive stopping on a single trip.

Demand and Potential demand were used as key factors for the location of Bus stops – Major trip generators i.e., areas with a high density of stops were considered for locating bus stops. Areas that had the potential to attract traffic due to future proposed development was also given priority.

Walking distance and waiting time – distance travel trip generators to originating bus stops. Perceived waiting time at the bus stops was considered a key factor because elongated waiting time affected commuters' willingness to take public transportation.

Junctions leading into housing estates, faculties, markets, and heavily populated nodes were given priority.

Carriageway width- Avoidance of conflicts that would otherwise impede bus, car, or pedestrian flows.

To flowchart below gives an indication of the logical sequence for selection of bus stops along the selected corridor.

Results

The generalization of findings from this study was subject to the data collected according to the specific time and routes. The survey was conducted during both peak and off-peak public transportation services.

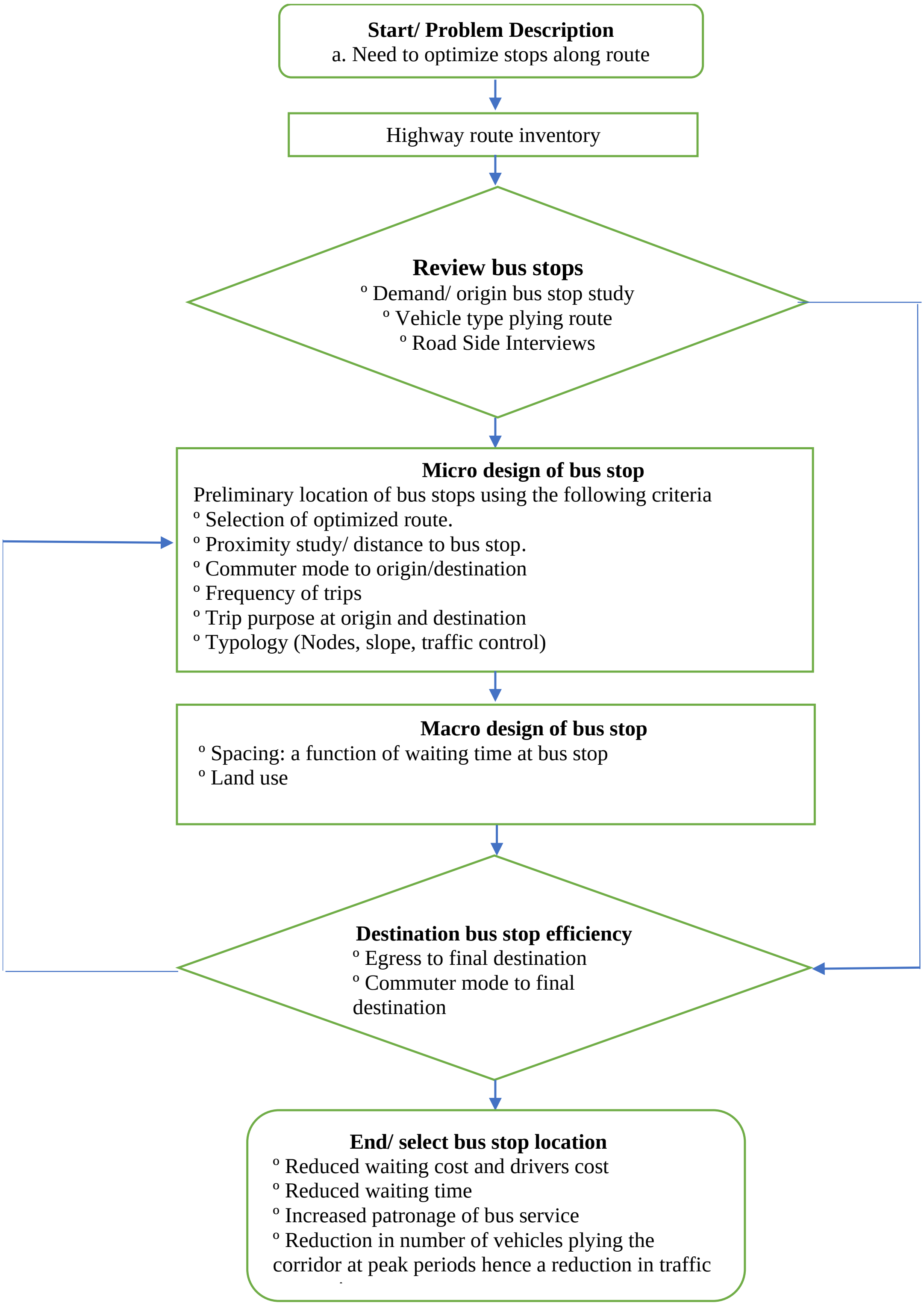


Figure.1: logical sequence in bus stop selection

Route Selection

The study identifies 15 nodes. Upon application of the Travelling salesman shortest route solver, only 10 of 15 nodes was visited, with a total distance of 19.96km covered as the optimum route distance.

Table.32: Shortest route using Excel Simplex LP method for optimisation

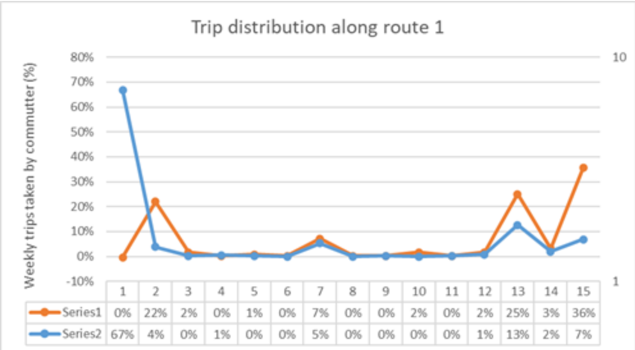
From	To	Distance (Km)	Go	Route	Nodes	Constraints	Equal To
A (origin)	B	1.57	1	A (origin)toB	A	0	1
B	C	10.10	1	BtoC	B	0	0
B	N	0.50	0		C	0	0
C	D	0.78	1	CtoD	D	0	0
C	M	2.98	0		E	0	0
D	L	2.21	0		F	0	0
L	D	2.21	0		G	0	0
D	E	1.18	1	DtoE	I	0	0
E	K	2.00	0		J	0	0
K	E	2.00	0		K	0	0
E	F	1.69	1	EtoF	L	0	0
F	J	2.44	0		M	0	0
J	F	2.44	0		N	0	0
F	G	4.00	1	FtoG	destination	-1	-1
G	destination	0.64	1	Gtodestination			
destination	I	0.73	0				
I	destination	0.73	0				
I	J	1.14	0				
J	I	1.14	0				
J	K	1.56	0				
K	J	1.56	0				
K	L	0.55	0				
L	K	0.55	0				
M	N	13.80	0				
Total length of shortest Route (km)				19.96			

The survey Identifies one administrative bus stop and several informal stops along the corridor. A total number of 108 nodes and 16 other trip generations were identified. 108 nodes leading to areas with significant population densities were identified, while facilities like shopping malls, hospitals, fuel stations, etc., were selected as possible trip generators. Vehicles along the corridor had established several informal stops that had a high percentage of stops several other stops introduced some stops on special request, these were not consistently included as informal bus stops.

Table.33:List of Identified Bus stops where stops occurred frequently

Origin/Destination Bus Stops					
			Coordinates		
S/N	Bus Stops	Chainage	Northing	Easting	Distance between Stops (m)
1	FUTMinna GK Roundabout	0+000	9°32'10.36"	6°27'17.96"	
2	FUTMinna Gidan kwano Gate	1+600	9°32'14.18"	6°28'3.18"	1600
2.1	Dama bus stop	3+300	9°33'3.81"	6°28'26.63"	1700
2.2	Gidan Mangoro bus stop	6+300	9°34'7.49"	6°29'38.36"	3000
2.3	Tunga Bus Stop	8+000	9°34'48.54"	6°30'15.99"	1700
3	Gurara Bus stop	9+800	9°35'29.86"	6°30'55.99"	1800
3.1	Gbeganu Bus Stop	10+300	9°35'37.29"	6°31'12.14"	500
4	Kpakungu Bus stop	11+800	9°35'54.53"	6°31'56.94"	1500
5	Market Bus stop	14+000	9°37'3.72"	6°31'41.45"	2200
6	Dusan Kura Bus stop	15+600	9°37'47.55"	6°31'15.93"	1600
7	Bosso Estate Bus stop	18+000	9°38'47.65"	6°30'46.39"	2400
7.1	Bosso back of FUTMinna	19+400	9°39'3.40"	6°31'16.78"	1400
8	Bosso Campus Bus Park	19+800	9°39'11.91"	6°31'25.98"	400

The Distance between stops was estimated from the track records on the GPS and the Odometer on the Vehicle. On starting the trip, the vehicle odometer was set to zero and the cumulative length of the trip was calculated taking note of the distance cover at the various stops. In addition to this, the GPS was also set to track the movement of the vehicle and the average speed and distance covered between stops are estimated.



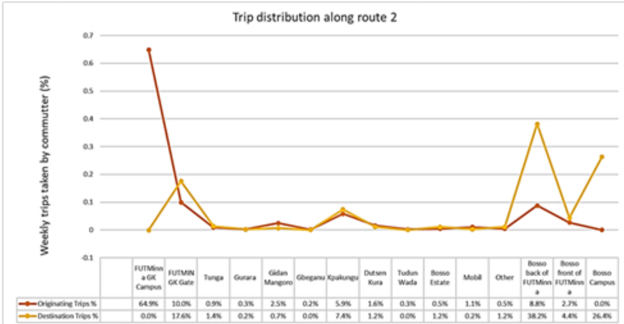


Figure 2: Trip distribution along selected corridor

The number of passengers traveling from the FUTMinna Bosso campus to the Gidan Kwano campus varied for the different bus stops, while the majority of the bus users came from specific terminals, some bus users came from various informal stops using less conventional means of transport. The following table shows the average waiting time in terms of journeys and the frequency of users on route one.

Table.34: Summary of Generated Trips & Bus users waiting time at designated bus stops

S/N	Origin Name of Place	Trip Origins		Trip destinations		Origin
		Number	Ratio (%)	Number	Ratio (%)	waiting Time (mins)
1	FUTMinna GK Campus	0	0	243	67	20 - 30
2	FUTMIN GK Gate	158	22	14	4	10 - 15
3	Tunga	12	2	1	0	11 - 15
4	Gurara	2	0	2	1	5 - 10
5	Gidan Mangoro	6	1	1	0	5 - 10
6	Gbeganu	2	0	0	0	5 - 10
7	Kpakungu	52	7	19	5	20 - 30
8	Dutsen Kura	2	0	0	0	20 - 30
9	Tudun Wada	2	0	1	0	21 - 30
10	Bosso Estate	12	2	0	0	20 - 30
11	Mobil	2	0	1	0	20 - 30
12	Other	12	2	3	1	30 - 60
13	Bosso back of FUTMinna	182	25	46	13	20 - 30
14	Bosso front of FUTMinna	24	3	7	2	30 - 60
15	Bosso Campus	258	36	25	7	5 - 10

Conclusions

In general, 13 bus stops were identified, compromising 2 administrative bus stations, 6 formal bus stops, and 5 informal stops. These bus stops account for the majority of trips along the corridor, the spacing between the stops on the corridor varies from 400m to 3,000m. the total length of the optimised route was 19.96km covering 7 major Nodes.

After the selection of the most efficient bus stop locations on the corridor, 6 bus stops were identified for route 1 and 6 bus stops for route 2. The Bus Terminal at the FUTminna campus was identified as the least optimal bus stop, this was because it provided the most traffic, yet the least comfort to respondents in terms of waiting time and distance to point of attraction.

Recommendation

The following recommendation were made:

a) A periodic review of bus stop efficiency should be carried out to meet up with the urbanization trends along the corridor.

Proper Bus stop laybys should be constructed to reduce the impact of vehicle parking.

Bus Stops should as much as possible be located at least 20 metres from any nodes or major traffic generators

The use of big buses should be encouraged to ease traffic congestion at bottlenecks like the Kpakungu roundabout.

Studies should be done on the effect of walking distances to trip generators and its effects on willingness to use public transport system along the corridor, a commuter in some cases have to walk long distances to the terminals to access bus services, this in turn encourages the need for other means of transportation within the university campus.

References

Adeleke, O., & Jimoh, A. (2012). Bus Stop location for improved movement on an Urban Arterial in Ilorin Metropolis, Nigeria. journal of Engineering Research.

Alexander, C., Ishikawa, S., & Silverstein, M. (2007). Pattern Language; : . Oxford University Press.

Alkheder, S., Taamneh, M., & Taamneh, S. (2016, 01 01). Severity Prediction of Traffic Accident Using an Artificial Neural Network: Traffic Accident Severity Prediction Using Artificial Neural Network. Journal of Forecasting, 36. doi:10.1002/for.2425

Bardi, E., Coyle, J. D., & Novack, R. A. (2016). Management of Transportation. Mason : Thomson : South-Western.

Brown, N. (1997). Accessibility and public transport experiment: Services and infrastructure. The University of London Centre for Transport Studies Working Paper.

Chen, S., & Chien, M. (2001). Dynamic freeway travel-time prediction with probe vehicle data: Link-based versus path based. Transportation Research Record.

Dell'Olio, L., Ibeas, A., & Cecín, P. (2010). Modelling user perception of bus transit quality. Transport Policy.

Drezner, Z., & Hamacher, H. (2002). Facility Location: Applications and Theory. Berlin: Springer.

Fernandez, R. (2009). Design of bus stop priorities. . Traffic Engineering and Control. 40., 335-340.

Fernández, R. (2010). Expert systems: Application to the location of high-capacity bus- stops. MSc Thesis, University of London.

Fernández, R. (2013). An expert system for the design and location of high-capacity bus- stops. . Traffic Engineering and Control.

Fernández, R., Brown, N., & Tyler, N. (2007). Accessible public transport routes in Brighton. Task 1: Western Road, Churchill Square area interim report. London: University of London Centre for Transport Studies.

Fielbaum, A., Jara-Díaz, S., & Gschwender, A. (2020). The role of line spacing in the strategic design of transit networks. Research in Transportation Economics.

García, C. R., Pérez, R., Alayón, F., Quesada-Arencibia, A., & Padrón, G. (2012). Provision of Ubiquitous Tourist Information in Public Transport Networks. Sensors, 11451-11476.

Gibson, J., Baeza, I., & Willumsen, L. (2009). Bus-stops, congestion, and congested bus- stops. Traffic Engineering and Control, 30(6), 291-302.

Gutin, G., & Punnen, A. P. (2007). The traveling salesman problem and its variations. Combinatorial Optimization, 527–562. Retrieved from https://learnesy.com/

Holroyd, E., & Scraggs, D. (2017). Waiting times for buses in Central London. Traffic Engineering and Control, 158-160.

leghorn, L. (2020). Optimum bus stop spacing: Part 1 and 2. . Traffic Engineering and Control 17(10), 472-475.

Moura, J., Alonso, B., Ibeas, A., & Ruisánchez, F. (2011). A Two-Stage Urban Bus Stop Location Model. Networks & Spatial Economics. NETW SPAT ECON.

Murray. (2010). A. A Coverage Model for Improving Public Transit System Accessibility and Expanding Access. Annals of Operations Research, 123(1–4), 143–156,

Murray, A. (2010). A Coverage Model for Improving Public Transit System Accessibility and Expanding Access. 123, 143-156.

Murray, A., & Wu, X. (2003). Accessibility Trade-offs in Public Transit Planning. Journal of Geographical Systems, 93-107.

Evaluation of the Impact of COVID-19 on Public Construction Project Delivery in Nigeria- a Review on Literature

Balogun, M. O.[1*] & Bilau, A. A.[2]
Department of Building, Federal University of Technology, Minna, Nigeria
oladimeji.pg2010926@st.futminna.edu.ng; aabilau@futminna.edu.ng

Abstract

Construction around the world is developing at a rapid rate both in terms of technology and in terms of organization. Construction industry is one of the most significant industries that contribute toward socio-economic growth especially, to developing countries and the Nigerian construction industry is not an exception. Construction project is a mission undertaken to create a unique facility, project or service within a specified scope, quality time, and cost.

The coronavirus COVID-19 pandemic is the global health crisis of the present time and one of the most significant challenges that the world has ever faced. The construction sector across the globe has been badly hit by the spread of COVID-19 virus and issues of contractual obligations, availability of resources, deliverables, health and safety measures and project delays or cancellations has been growing concern. This study aims to evaluate the impact of Covid-19 pandemic on public building construction delivery in Nigeria with a view to proffer strategies to mitigate the impact. The study adopts a literature review methodological choice to investigate the study.

Findings of similar impacts are extensively reported in the literature. However, the impact of covid-19 affected the completion date and this was affected in terms of social, economic, cost, time and resources. In conclusion as a result of covid-19, construction have been compelled to adjust to substantial obstacles and impacts, as well as devise project-by-project solutions to alleviate delays and other covid-19 related problems while maintaining the interests of construction. And it also revealed that a better understanding of this impact would help the construction industry proffer strategies that could be applied to mitigate the impact of Covid-19 pandemic on effective building construction project delivery. The outcome of this project may also apply to other sectors of the economy and countries globally.

Keywords: Construction; Covid-19; Public Construction Project; Delivery

1.0 Introduction

Construction around the world is developing at a rapid rate both in terms of technology and in terms of organization (Henry and Okereke 2020). Construction industry is one of the most significant industries that contribute toward socio-economic growth especially to developing countries and the Nigerian construction industry is not an exception to this (Saidu and Shakantu 2017). According to (Mangvwat et al. 2019), the construction industry contributes about 3% to Nigeria's Gross Domestic Product (GDP). Construction creates, builds and maintains the workplaces in which businesses operate and flourish, the homes in which people live and the schools, hospitals that provide the crucial services that society needs and the important economic infrastructure like roads, which keeps the nation, connected (Department of Business Innovation and Skills, 2013). Historically, a project is successful when it is complete on time, within cost, and in accordance with stakeholders' specification. Going by these criteria, project success is not commonplace because most construction projects encounter delayed completion. Aibinu and Jagboro (2002) noted that this stems from the findings that projects are generally characterize by long delays. This is because construction projects are expose to uncertain environments such as construction complexities, presence of various interest groups such as project owners, end users, consultants, contractors, financiers, and issues relating to materials, equipment, and funding, climatic conditions, economic, political, environmental and pandemics.

The coronavirus COVID-19 pandemic is the global health crisis of the present time and one of the most significant challenges that the world has ever faced. Since emergence of this disease in Wuhan, China, towards the end of 2019, the virus keeps spreading across the globe (Mizutori, 2020). Covid-19 pandemic is on a far greater geographic scale that affects a much large number of people (Maital &

Barzani, 2020). Halpin (2006) reported that public building construction project delivery is the organization or the development of the framework relating the organizations required to complete or deliver a project. However, pandemic affected the completion date and this was affected in terms of cost, time and resources. Unforeseen circumstance can occur and often unavoidable during the construction process, which can lead to overruns and elongated the time schedule for the project to be delivered (Abdul-Rahman, 2008). Projects delivery is one of the most critical issues, Unfortunately, government policy makers and planners do not seem to learn from past mistakes, as the magnitude of completion time has not improved over the last several decades and this have been major challenges in construction industry (Flyvbjerg, Holm & Buhl, 2003).

The public building construction project delivery entails in cost, time, resources and quality standards this is because clients usually demand for a better value on investments. As such, they want projects to be completed on time, within cost and with the right quality Idoro, G. I. (2012).

2.0 Literature Review

Pandemics/Epidemic in the Construction Industry

An epidemic is an event in which a disease is actively spreading. Generally, an outbreak has grown out of control but is often within one country or location. A pandemic is on a far greater geographic scale that affects a much large number of people (Maital & Barzani, 2020). The pandemic was marked as a global pandemic by the WHO has not only infected on the human life but also effected the global economy which having a potential of destroy the livelihoods, industries, businesses and the entire economy in a larger scale (Laing, 2020). The particular disease evolved like a pandemic with the extensive spread within the number of nations all over the world (Hamid & Huam, 2020).

Therefore, there is a need for a more accurate macroeconomic model of economic effects across sectors and countries, especially in West Africa, which should be consistent with the WHO benchmark to recognize the economic consequence of injury and disease. A local assessment of the COVID-19 impacts on the Nigerian economy showed that the pandemic led to a significant fall in demand except for purchases by the government (Onyekwena and Ekeruche 2020). However, Zhang et al. (2020) emphasized that the lasting effect of the pandemic may include business failures and mass unemployment coupled with hardships for many industries. Table 1 shows the impact of pandemics and epidemic on some selected SSA Countries.

Impact of pandemic on public building construction project

Since its emergence in January 2020, the impact of the covid-19 pandemic across the length and breadth of nations and continents around the globe. covid-19 has a socio-economic impact on the economy of countries through direct and indirect ways. Directly, through the effects of the disease on production, investment, international trade and human life, especially on the most vulnerable people's health and vigor; and indirectly, by slowing global economic growth, disrupting the supply chain and, by extension, adversely affecting a nation's growth itself (Amponsah & Frimpong, 2020). The construction industry, especially in many countries, has been impacted due to the covid-19 pandemic. Some of the pandemic challenges include the unavailability of resources and deliverables, contractual obligations, health and safety constraints, low productivity, project delays and terminations. The perception of change regarding schedule impacts in the coming months will affect commercial construction sectors. Much of the disruption in the construction sector is in the supply chain (Simpeh & Amoah, 2020). However, due to the rise in the number of cases of the virus, several ongoing projects had to be stop except those considered by the Government as essential (Amponsah & Frimpong, 2020). Many contractors and builders are now struggling to obtain permits for both in process and new projects (Anyango, 2020). Even though construction companies want to resume their operations, governments' new regulations and guidelines have created uncertainties for the construction firms and their workers. Homeowners in areas with high virus cases are restricting contractor access and entrance into their homes (Babar, 2020). Gumble (2020) stressed that the construction industry would not be the same again once the pandemic is over.

Table 1: Previous Pandemic/Epidemic Reported in Literature

Pandemic / Epidemic	Country	Impact	Source
Coronavirus	Nigeria, Cameroon and South Africa	Loss of lives Capital flight Wealth depletion Increased inequalities Job and livelihood loss High health expenditure Reduction in social spending	United Nations [UN] (2020)
	Nigeria	Debt crisis Decline in oil price Stock market crash Reduction in National budget Shortage of crucial supplies	Ozili (2020); Adenomon *et al*. (2020); UN (2020)
	Ghana	Downward review of 2020 GDP growth forecast from 5.8% to to 1.5% Decrease in export earnings Decline in foreign direct investment	Aman (2020); United Nation Development Group (2015)
Influenza	Nigeria	Fall in consumption of poultry product Decrease in agriculture GDP Loss of Job Increase in the unemployment rate Increase in malnutrition level Difficulty in loan recovery by the bank	Obayelu (2007); Owai (2010)
	Ghana	High bird mortality rate Production and revenue loss Fall in consumption of poultry product Restricted movement of poultry product High cost of biosecurity measure Sales reduction of veterinary drug	Tasiame et al. (2020); Akunzule et al. (2009)
Ebola	Liberia	A decline in government revenue Loss of investors' confidence Low agricultural production and marketing system 18.7% GDP loss between 2014-2017 Increase in the poverty rate 8% reduction of the healthcare workforce	CDC (2014); Smith et al. (2019); UN (2020)
	Sierra Leone	50% loss of workforce (Private sector) 23% decrease in health service delivery 7.1% loss of average GDP (2014-2017) Increase in the poverty rate Food insecurity	CDC (2014); Smith et al. (2019); UN (2020)
	Guinea	Loss of investor confidence Increase in the poverty rate A decline in government revenue	Smith et al. (2019)

(Source: Olanrewaju *et al*., 2022)

With various restrictions put in place, the virtual environment will be integrated into construction activities as a new normal. Kale (2020) shared a similar opinion, as Gumble (2020) and re-iterated that there is the possibility of many office-based construction roles done at home. In Jones's (2020) view, it is about time the construction industry fully embraced technology in their activities, as this is the only safe way to observe key protocols like social distancing. According to Ogunnusi *et al.* (2020). Doddy and Sorohan (2020) conducted a study to reveal how the construction industry can take proactive steps to mitigate the impact of covid-19 restrictions. In the survey, Doddy and Sorohan (2020) stressed that the pandemic's impact is likely to be felt through all segments in the construction industry, both financially and operationally. The operational implications are report to be feel by the people, supply chain, current contracts and sites. The financial repercussions can be feel in the funders, the working capital and the revenue (Doddy and Sorohan, 2020).

Table2: The impact of covid-19 on main categories of construction projects (Farid Ghazali, 2021)

Financial Issues	Consumption reduction
	Supply chain disruption
	Rises of taxes
	Loss of profits
	Funding problems
Contractual Impact	Termination
	Time overruns
	Project suspension
Technical Issues	Workforce productivity
	Lack of skilled workers
	Poor quality
	Impact on technology
Socioeconomic Impact	Labour shortage
	Health & Safety
	Government unpredicted lockdown

3.0 Research Methodology

This study adopts a literature review methodology to carry out this research by exploring various data based to collate past related work

4.0 Discussion of Findings

Findings of similar impacts of the pandemic are extensively reported in the literature (Araya, 2021; Simpeh and Amoah, 2021; Gilbane, 2020; Bailey, 2020; Alenezi, 2020; Nicola et al., 2020; Babar, 2020). As indicated by Kazeem (2020), "with business ventures that require daily activity to earn income, a weeks-long hiatus from work can translate to financial disaster". By staying home for so long, many construction workers, especially the casual staff either had no access to affordable food or had run entirely out of money to buy food due to lack of funds. There were concerns that if Governments did not intervene quickly, hunger would kill more vulnerable people in many countries than the covid-19 disease (Bagnetto, 2020).

The covid-19 pandemic has substantially affected construction projects, its legal implications vary from contract to contract and from nation to nation. Bailey *et al.* (2020) posited that the pandemic has not only rendered projects incomplete but has also slowed down and delayed project completions. There are reports of projects that have stopped completely to commence work on later dates (Bailey *et al.*, 2020). The health and safety management plans of construction companies have also been affect, as health and safety risk assessments now have to be consistent with scientific, medical and Government guidelines (Baileyetal, 2020). Hook (2020) was also of the view that the pandemic's impact force some construction companies to streamline debts, consider various means of funding or risk bankruptcy. Ogunnusi *et al.* (2020) further stressed that should the situation remain the same or worsen, there is the potential for construction companies to encounter limitations in resources.

Economic impacts

The findings from this study agree with Likitha et al. (2022), where it was stated that COVID-19 impacts have resulted in the postponement of infrastructural projects, time overrun, labour impact, job loss, and cost overrun. Das et al. (2022) affirmed that the COVID-19 pandemic had a great economic impact in all sectors. Jeon et al. (2022) also expressed that the pandemic impact is evident in the economic aspect of the Purdue Index for Construction. This connotes that the COVID-19 pandemic is critical to the economic performance of the construction industry.

Environmental impacts

Alfadil et al. (2022) showed through a systematic literature review that environmental factors affect construction project success. Saadat et al. (2020) reported that air and water quality improved significantly across the globe during the COVID-19 pandemic. The improved environmental condition also came with a price. It was noted in previous studies that the amount of medical waste increased sporadically due to the huge demand for COVID-19 medical supplies (Saadat et al. 2020; Zhao et al. 2021; Urban and Nakada 2021). Kawka and Cetin (2021) and Rouleau and Gosselin (2021) reported that the pandemic resulted in over 50 to 100% significant energy usage. Nonetheless, COVID-19 seems to have a moderately positive environmental impact on the environment due to a reduction in the use of construction machinery and activities that helped lower the high rate of emissions attributed to construction activities. This can be attributed to the reason the environmental impact of the pandemic is low compared to other impact categories (economic and social).

Social impacts

It includes impacts such as an increase in unemployment, disruption of construction supply chains, increased poverty rate, and loss of lives. These findings concur with Ogunnusi et al. (2020), which acknowledged the negative impact of the pandemic on the construction supply chain. Jeon et al. (2022) expressed that the impact of the COVID-19 pandemic is not evident in the social aspect of the Construction. In contrast, studies have also reported a significant increase in unemployment owing to the negative influence of the COVID-19 pandemic on construction firms (Afkhamiaghd and Elwakil 2020; Biswas et al. 2021; Alsharef et al. 2021). Osterrieder et al. (2021) emphasized that COVID-19 measures have unequal social and economic impacts on people from different regions. This indicates that stakeholders need to understand and address the social risks attributed to COVID-19 for better performance of the industry

5.0 Conclusion and Recommendation

As a result of covid-19, construction have been compelled to adjust to substantial obstacles and impacts, as well as devise project-by-project solutions to alleviate delays and other covid-19 related problems while maintaining the interests of construction.

Various publication have released articles on how to overcome the impact of Covid-19 pandemic on construction which has proven to be helpful in our daily site activities but although also came with its own challenges. though the covid-19 pandemic has substantially affected construction projects, its legal implications vary from contract to contract and from nation to nation. The pandemic has not only rendered projects incomplete but has also slowed down and delayed project completions. There are reports of projects that have stopped completely to commence work on later dates. The health and safety management plans of construction companies have also been affect, as health and safety risk assessments now have to be consistent with scientific, medical and Government guidelines.

Recommendation

As the symptoms of the Coronavirus spread over globe, government and corporations should focus their efforts on ensuring the safety of their citizens.

Reference

Agyekum, K., Kukah, A. S., Amudjie, J., Al, N. et, Amponsah, Anyango, Sorohan, D., Kazeem, Bagnetto, Service, G. S., Al, A. et, Braimah, K. &, & Mills, A. &. (2022). The impact of COVID-19 on the construction industry in Ghana: the case of some selected firms. *Journal of Engineering, Design and Technology*, *20*(1), 222–244. https://doi.org/10.1108/JEDT-11-2020-0476

Ahmed, S., & El-sayegh, S. (2021). *Critical Review of the Evolution of Project Delivery Methods in the Construction Industry*.

Aibinu, A. (n.d.). *The effects of construction delays on project delivery in Nigerian construction industry*.

Al Amri, T., & Marey-Pérez, M. (2020). Impact of Covid-19 on Oman's Construction Industry. *Technium Social Sciences Journal*, *9*, 661–670. https://doi.org/10.47577/tssj.v9i1.1021

Ameh, O. J., & Osegbo, E. E. (2011). Study of Relationship Between Time Overrun. *International Journal of Construction Supply Chain Management*, *1*(1), 56–67.

Araya, F., Sierra, L., & Amoah, S. and. (2021). Influence between COVID-19 impacts and project stakeholders in Chilean construction projects. *Sustainability (Switzerland)*, *13*(18). https://doi.org/10.3390/su131810082

Bashir et al., 2010. (2021). *Users ' assessment of conduciveness of campus infrastructure at Federal University of Technology Minna*.

Biswas, A., Ghosh, A., Kar, A., Mondal, T., Ghosh, B., Bardhan, P. K., 2011, forbes and ahmed, Hook, Jonathan, Statista, Hui, M., Davies, A., Ross, & Dennis. (2021). The impact of COVID-19 in the construction sector and its remedial measures. *Journal of Physics: Conference Series*, *1797*(1). https://doi.org/10.1088/1742-6596/1797/1/012054

Bitamba, B. F., An, S. H., Abera, Nor, 2012, Al, B. et, Al., M. et, & Al., G. et. (2020). Study on factors affecting the performance of construction projects in the democratic republic of the Congo. *South African Journal of Industrial Engineering*, *31*(1), 12–25. https://doi.org/10.7166/31-1-2193

Davis, S. D., Seibels, M., & Prichard, R. G. (n.d.). *Cost reduction strategies for contractors* (pp. 1–14).

Dey, S., Samanta, P., Ghosh, A. R., & Al, N. et. (2021). *Disaster &*. *March*.

Elinwa, A. U., & Joshua, M. (2001). Time-Overrun Factors in Nigerian Construction Industry. *Journal of Construction Engineering and Management*, *127*(5), 419–425. https://doi.org/10.1061/(asce)0733-9364(2001)127:5(419)

Elsayah, O. S., Al, H. et, Naoum, & Saul. (2016). *A Framework for Improvement of Contractor Selection Procedures on Major Construction Project in Libya By*. *July*.

Fidic, T. H. E., Principles, G., Causes, C., Hammad, A. W., Akbarnezhad, A., Rey, D., Li, X., Xu, J., Zhang, Q., Xu, N., Xu, Q., Li, Q., Besaiso, H., Fenn, P., Emsley, M., Wright, D., Shweiki, I., Conditions, G., Samir, S., … Al., S. et. (2017). F a c t o r s A f f e c t i n g t h e P e r f o r m a n c e o f C o n s t r u c t i o n P r o j e c t s i n t h e G a z a S t r i p. *Engineering, Construction and Architectural Management*, *25*(2), 657–667. http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Factors+Affecting+the+Quality+of+Design+and+Contractual+Documents+in+Gaza+Strip#0%0Ahttps://doi.org/10.1016/j.proeng.2017.01.214

Flyvbjerg, H. & B. (n.d.). *Causes of Cost Overrun in Construction Industry*.

Gamil, D. Y., Alhagar, A., Al., N. et, & Hui et al. (2020). The Impact of Pandemic Crisis on the Survival of Construction Industry : A Case of COVID-19 Dr . Yaser Gamil Abdulsalam Alhagar. *Mediterranean Journal of Social Sciences*, *11*(4), 122–128.

Gamil, Y., & Alhagar, A. (2020). The Impact of Pandemic Crisis on the Survival of Construction Industry: A Case of COVID-19. *Mediterranean Journal of Social Sciences*, *11*(4), 122. https://doi.org/10.36941/mjss-2020-0047

Ghandour, A., & Chopra. (n.d.). *THE IMPACT OF COVID-19 ON PROJECT DELIVERY : A PERSPECTIVE FROM THE CONSTRUCTION SECTOR IN THE UNITED ARAB EMIRATES*.

Ghazali, F. (2021). *The Impact of COVID-19 and Control Strategies Adoption in the Construction The Impact of COVID-19 and Control Strategies Adoptionin the Construction Sector*. *August*.

Guan, D., Wang, D., Hallegatte, S., Huo, J., Li, S., Bai, Y., Lei, T., Xue, Q., Davis, S. J., Coffman, M., Cheng, D., Chen, P., Liang, X., Xu, B., Lu, X., Wang, S., Hubacek, K., & Gong, P. (n.d.). *Global economic footprint of the COVID-19 pandemic*.

Halpin, 2006), Asmar, & 2010, N. et al. (n.d.). *EVALUATION OF INTEGRATED PROJECT DELIVERY ON THE PERFORMANCE OF CONSTRUCTION PROJECTS*.

Hamid. (n.d.). *Study the impact of the COVID-19 pandemic on the construction industry in Egypt*.

Henry, A. C., Okereke, R. A., Baake, K., Ayuba, Olagunju, and A., 2020, H. and O., 2020, H. and O., & 2003, I. (2020). Construction Project Delivery in a Deregulated Economy. *International Journal of Engineering Applied Sciences and Technology*, *5*(1), 61–66. https://doi.org/10.33564/ijeast.2020.v05i01.009

Hosseini, A., Lædre, O., Andersen, B., Torp, O., Olsson, N., Lohne, J., & 2006, C. (2016). Selection Criteria for Delivery Methods for Infrastructure Projects. *Procedia - Social and Behavioral Sciences*, *226*(September 2015), 260–268. https://doi.org/10.1016/j.sbspro.2016.06.187

Kasimu. (n.d.). *Exploring_anti-corruption_capabilities_of_e-procur*.

Kivrak, S., & 2005, M. (n.d.). *Improving sub-contractor selection process in construction projects : Web-based sub-contractor evaluation system ... Ci*. https://doi.org/10.1016/j.autcon.2007.08.004

Laing, 2020, & Critelli, 2020. (2021). Impact of Covid-19 Pandemic on Construction Sector of Nepal. *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN Laing*, *18*(1), 25–30. https://doi.org/10.9790/1684-1801032530

Le, H., & Bui, Nhu, R. (2022). *Attitude toward preventive measures during COVID-19 Department of General Psychology Bachelor ' s Degree Course in Psychological Science Final* dissertation *ATTITUDE TOWARD PREVENTIVE MEASURES DURING COVID-19 Supervisor Candidate : BUI LE NHU HAO Student I*. *June*, 0–39. https://doi.org/10.13140/RG.2.2.16226.20160

Mangvwat, J. S., Olumide, O. S., Yahaya, A. M., Zakka, P. W., Job, F. O., & Mangvwat et al. 2019. (2019). *Effects of Time Overrun on Construction Projects within Jos Metropolis, Nigeria*. *4*(1), 18–28.

McLin, M., Doyon, D., Lightner, B., Federle, M., & NECA. (2020). *Pandemics and Construction Productivity: Quantifying the Impact*. *August*, 1–30.

Ngwoke, D., Sunday, M., & Okoh, O. (2015). *Productivity Improvement in Construction Project Delivery*. *7*(10).

Ofori, G., & Bowen. (n.d.). *Challenges of Construction Industries in Developing Countries : Lessons from Various Countries*.

Oga Ojoko, E., & OSHA. (n.d.). *Impact of Covid-19 on Construction Project Performance in Nigeria and Mitigating Measures: The Stakeholders' Perception Identification and Analysis of Critical Success Factors Influencing IBS performance in Housing Delivery View project Oil Palm Waste Vol*. https://www.researchgate.net/publication/348602917

Phimister, Obayelu, Toole, J., Yeoman, Meintjes, Harinarain, Zengeni, Z. &, & Flynn, M. (2021). *The Impact of the COVID-19 on the Construction Industry in Vietnam*. *8*(3), 47–61. https://doi.org/10.11113/ijbes.

Runyon, A. N., & 2007, A. (2019). Submitted By : بسم الله الرحمن الرحيم. *Academia.Edu*, 1–189. https://minervaaccess.unimelb.edu.au/handle/11343/56627%0Ahttp://www.academia.edu/download/39541120/performance_culture.doc

Saidu, I., Shakantu, W., Abdul-rahman, & Endut. (2017). An investigation into cost overruns for ongoing building projects in Abuja, Nigeria. *Acta Structilia*, *24*(1), 53–72. https://doi.org/10.18820/24150487/as24i1.3

Salman, H., Kouider, T., Gumble, Kale, Al, O. et, & Al, B. et. (2020). *COVID-19 Pandemic: The Effects and Prospects in the Construction Industry*. https://www.researchgate.net/publication/346411838

Shehu, S., & Nagar. (2022). *A REVIEW OF TIME MANAGEMENT FACTORS IN CONSTRUCTION PROJECT A Review of Time Management Factors in Construction Project Delivery*. *1*(October). https://doi.vorg/10.22452/jpmp.vol1no2.3

Appraising Household's Sewage Management Practices in Samaru-Zaria, Kaduna State, Nigeria

Habila, S.K.[1a], Itopa, W.I.[1b], Ode, I.[1c], Akan, M.[1d] & Lawal, H.[1e]

[1]*Department of Urban and Regional Planning, Ahmadu Bello University, Zaria-Nigeria*

shabila962@gmail.com; wiibrahim@abu.edu.ng, odesamsonigo@gmail.com; realmarcus2015@gmail.com; harfceelah@gmail.com;

***Abstract**:*

This paper appraises the activities of Households Sewage Management Practices in Samaru, Zaria. Kaduna State. Nigeria, with the sole aim of establishing a baseline data that would aid intervention towards achieving sustainable practice. Sixty Households (60) were sampled out of five hundred and ninety-two (592) houses sourced from global mapper digitised attribute data and 60 copies of questionnaire administered to the selected houses each. A face-to-face key informant interview was conducted on one (1) Private Sewage Service Provider. Data were analysed using Microsoft Excel 2010 version in computing percentages of responses and descriptive statistics was used in discussing the deduced data accordingly. Pictures were used to add facts to findings. The study ascertained that, majority (55%) of households use Water Closet (WC). most (55%) households release their sewage outside septic tank, with 62% outlet into open drainages, majority (92%) empty of containment immediately when full, most (85%) do not dump materials into septic tank. Most Households (55%) empty septic tank when full, majority (45%) pay N15, 000 for emptying services, while, most (77%) households are satisfied with the services of the PSSPs and many (62%) households object to cost increase from PSSP services. Only one commissioned PSSP render services offers domestic sewage emptying and disposal in Samaru, Zaria and is has challenges such as. inadequate vacuum trucks and poor access to septic tank man hole for emptying services and the disposal of hard materials into containment. Recommendations were provided to ameliorate the challenges towards sustainable practice.

Keywords: Disposal, Households, Sewage, Sanitation, Waste-water.

INTRODUCTION

Sewage or wastewater management refers to the storage, collection, transport, treatment and safe end use or disposal of wastewater (United Nations Environmental Programme, 2020). The integration of effective, efficient and eco-friendly sewage management practice into the operation and life cycle of cities especially at the household level is necessary for achieving Sustainable Development Goal 6.2 (Oji et al., 2018). Studies by Mukherjee et al. (2019); Diop and Mbéguéré (2017); Muxímpua et al. (2017) had established the need to improve wastewater management from containment to final disposal or reuse. Good practices do not only mean the presence of technological innovation, but also a well-structured institutional arrangement that considers relevant stakeholders / actors, including marginalized groups. Proper coordination on roles and responsibilities actors such as households (generators of sewage) and the sewage service providers, is required for effective management (UNEP, 2020).

World Health Organisation (WHO)/UNICEF (2015) reports that only 38% of the population in the least developed countries had access to improved sanitation facilities. Cities with adequate sanitation facilities are usually confronted with problems of poor operations and maintenance. Thus, households experiencing varying problems of inadequate sanitation options and sanitation services delivery adopts numerous coping strategies (Abubakar, 2017). Some of which involve changing service provider, obtaining services from alternative sources such as emptying and final disposal of domestic sewage by private and sometimes informal collectors. Conceivably, the sewage management practices of household tend to contribute to environmental pollution and spread diseases while the Sewage Governance/ Institutions statutorily tasked for emptying and final disposal of sewage from on-site systems seems to have inadequate capacity to handle such roles (Mukherjee et al., 2019; Abubakar, 2017).

The efficiency of a municipal sewage management scheme and services alongside the household's management practices needs to be studied and documented so as to establish baseline data for intervention towards implementation. Owing to the fact that Nigeria is amongst the Sustainable Development Goals Region and its cities signatories to the global alliance to SDG 6 and 11 on sustainable sewage management and realisation of functional, liveable and sustainable cities. These inspired the thrust to appraising the activities of households' sewage management practices in Samaru, Zaria. Kaduna State. Nigeria, with the sole aim of establishing a baseline data that would aid intervention towards achieving sustainable practice through establishing the household sanitation systems and emptying practices, assessing the resident's perception on the service providers, and evaluating the operations of the services providers. The outcome of this paper should be helpful to policy formulation of a city- wide scheme on Municipal Sewage Management in Zaria Urban Area (ZUA) through appropriate recommendations for practicable implementation.

LITRATURE REVIEW

Sanitation is the means necessary to dispose of human excreta and waste water safely (Verhagen and Ryan, 2008). Despite renewed focus and increased investments in recent years, urban sanitation strategies and planning frameworks are not yet adequate to achieve the Sustainable Development Goal target (6.2) for adequate and equitable sanitation (Scott, et al., 2019). Sewage which is water-carried wastes either in solution or suspension that flow away from a community can be classed as sanitary, commercial, industrial, or surface runoff depending on their origin (Ibiam and Igewnyi, 2012). SIDA estimates that an average person produces 50 litres of (dry) faeces and 400-500 litres of urine annually (Verhagen and Ryan, 2008). The amount of grey-water generated varies enormously (from 4,500 to 73,000 litres) and is dependent on the availability of supply and how close to the final point of use it is brought. Even small amounts of faeces pose a significant threat to health. Whatever the density of the settlement, urine, faeces, and grey water have to be disposed of in a safe and sustainable manner and the denser the settlement, the more problematic it becomes to do this safely (Verhagen and Ryan, 2008).

Sewage management deals with various ways sewage could be treated to the advantage of man while reducing the negative effect on the environment. The processes involve collection of the sewage, treating, screening and disposing them in a way that it will not pose any hazards to man environmentally or health wise. This requires infrastructure and planning, which are lacking in many countries of Africa. Where available, existing treatment facilities are often underutilized or overloaded, and release untreated or partially treated effluent into the environment (UNEP, 2020).

Wastewater accumulated in on-site sanitation systems such as septic tanks and pits needs to be periodically removed and treated before it can be safely disposed of the environment. The responsibility of managing wastewater within residential structure is that of the households while the responsibility for providing septic tank emptying services rests with local authorities, in reality the septic tank emptying and transportation business is operated largely by private sewage service providers, albeit informally. Further, due to non-implementation and enforcement of regulations, the collected wastewater is dumped by households indiscriminately in open areas (sometimes discharged unto the streets) and water bodies both within and outside cities and towns, leading to environmental pollution (Mukherjee et al., 2019).

According to Joseph (2006) the roles of households as key stakeholders in sewage management include; practicing source reduction and source segregation where necessary, cooperating with civic bodies in identification of sites for sewage management facilities and their operation and paying for sewage management services. Similarly, the Kaduna State Environmental Protection Agency (KEPA) regulations on control of water pollution sources states that it is the duty of every owner of any premises in the State to provide a latrine or make adequate provision for the collection of human excreta in the premises and also the duty of occupiers of any premises to regularly maintain any latrine, soak away pit, septic tank, or water carriage system of latrine and keep latrines in clean and good condition. The duties and responsibilities of households in sewage management process often varies from place to place and so also is the practices employed by these households in managing sewage. According to Jeuland et al. (2004), differentiation should be made between "willingness-to-pay" and "ability-to-pay" due to the fact that there is little correlation between the willingness-to-pay and relative wealth of households. The high price of sewage management services almost certainly helps to explain why households tend to wait until their installations are nearly overflowing to call for the service (Jeuland et al., 2004).

Case studies of Household sewage management practices

Bamako, Mali

Jeuland et al. (2004) reported that in Bamako, households were generally organized into one-family concessions, grouping together large numbers of relatives (often > 10 people) in one or several buildings around one central courtyard. For those able to pay for them, internal bathrooms tend to be connected to septic tanks by flush systems, but most families also have outside latrines or flush systems as well, to be used by children or household servants. Over 99% of the population uses on-site sanitation (OSS) installations, with only the major hotels and a few places in the centre of the city connected to sewer-type systems (Jeuland et al., 2004). When identifying the combination of criteria that determine when the households call for emptying service, the distribution shows that only full pits really bring about cleaning actions and services. After those conditions are reached, 98% of those surveyed call the service in the following days, lending credibility to the idea that households are "able-to-pay" when they need to (Jeuland et al., 2004).

Son La, Lang Son, Hoa Binh, Bac Ninh, and Ba Ria, Vietnam

According to Bassan et al., (2014) reported that flush toilets connected to septic tanks were the most common type of sanitation technology used by the surveyed households in the five cities of Vietnam. They were utilized by 98% of surveyed households in Bac Ninh, 100% in Ba Ria, 95% in Son La, 95% in Lang Son, and 94% in Hoa Binh. The percentage of household discharging the septic tank supernatant in soak pit or open areas varies between 44% in Lang Son, and 2% in Bac Ninh. 2% of interviewed households in Bac Ninh and Lang Son have no toilet and practice open defecation due to limited budget. Among surveyed households, very high percentage did never empty their septic tank, accounting for 81%, 86%, 80%, 89%, in Bac Ninh, Son La, Hoa Binh, and Lang Son, respectively. In Ba Ria 39% of surveyed household having a septic tank did never empty it. This can be explained as most of the septic tanks (73%) were built less than ten years ago, when the mean estimated emptying frequency reaches 10 years. In general, only a small part of the septic tanks that were built less than 5 years ago has been emptied. In Ba Ria, about 27% of these were emptied. In all other cities, this percentage is less than 10%. The emptying rate for onsite systems of 5 to 10 years is also better in Ba Ria, with 41% of the systems of this age which were emptied. In average, 25% of the onsite systems having between 10 and 20 years were emptied. As more than 70% of the households have a septic tank that was built less than ten years ago, it is expected that more and more sewage will be emptied the coming 5 to 10 years, when these will fill up. The study emphasizes the urgent need to find solutions for the management of sewage in the five cities, as well as in other cities presenting similar situation (Bassan et al., 2014).

STUDY AREA

The case study area is Samaru in Zaria urban area; this is one of the residential neighbourhoods from the several others that make up the Zaria urban centre. Samaru is bounded by Ahmadu Bello University from the south-west and a rail line from the north-east. The study area is hosting the Nigerian Institute of Leather and Science and Technology. Samaru shares a common feature as per climatic conditions with the general characteristics of the climate in Zaria urban area. Zaria in general has a tropical Savannah climate (Koppens Climate Classification), which is characterized by warm weather all year-round, a wet season normally lasting from April to September but most recently to October and a drier season from October to March.

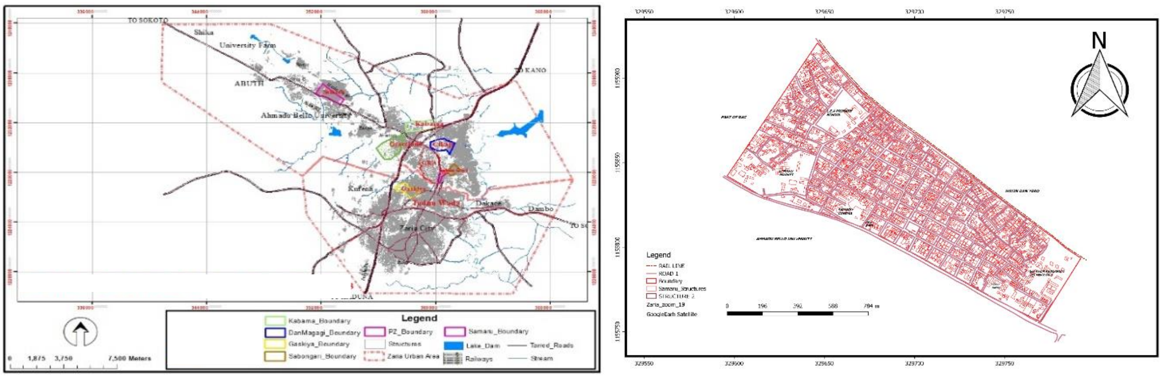


Figure 1: Zaria urban area and base map of Samaru

METHODOLOGY

Sixty Households (60) were sampled out of five hundred and ninety-two (592) houses sourced from global mapper digitised attribute data using the Frankfort Nachimas sample size formula and 60 copies of questionnaire administered to the selected houses each. A well-structured questionnaire incorporating the sanitation option, emptying practices and respondent's perception of the operation of the emptying service providers was administered to the residents of Samaru residential area. The sampled households were selected at random from the total number of the households. Households from various locations within the study area were selected to give adequate coverage of the entire area. The research also conducted a face-to-face key informant interview with the CEO of Shirash Petroleum Service Limited which was the only commissioned company providing sewage emptying services in Zaria, with the aid of an interview guide. Data acquired were analysed using Microsoft Excel 2010 version in computing percentages of responses and descriptive statistics was used in discussing the deduced data accordingly.

RESULTS AND DISCUSSIONS

A total of 60 questionnaires were administered based on the number of households. Section A & B analyses the household's sewage management practices while Section C discussed the practices of the service providers in Zaria.

Household sanitation systems and emptying practices

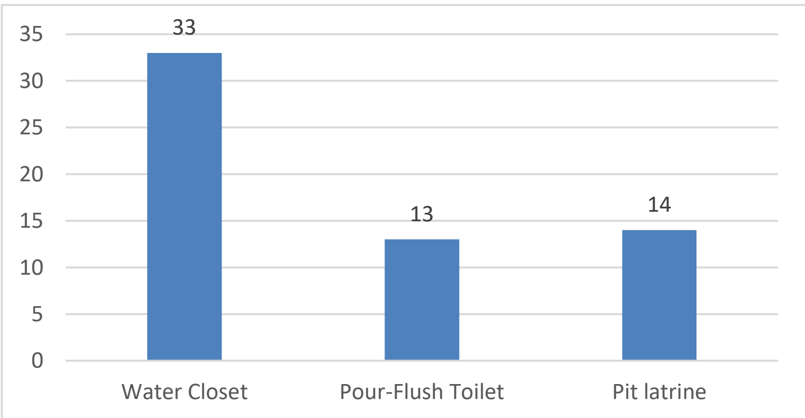


Figure 2: Types of sanitation facility

Flush toilets connected to septic tanks are the most common type of sanitation technology used by the surveyed households. As shown in Figure 2, most of the respondents have flush toilet with a percentage of 77 percent out of which 55% are water closet and pour-flush amounting to 22%. The remaining 33% utilised pit latrines. These high percentages confirm the importance of implementing adequate and environmental-friendly sewage management system. The type sanitation option used by the residents determines whether the sewage can be easily evacuated from the on-site systems. Additionally, the types of facility used was also found to determine the possible type of emptying services (mechanical or manual) used as the presence of water in the on-site system facilitate easy evacuation of sludge with mechanical vacuum truck compare to the pit latrine where the use of water is optional.

Plate 1,2 and 3: Water closet, pour-flush and pit latrine types of sanitation facility

In response to the act of disposing other materials like solid waste, oil, and even chemicals to improve degradation into the septic tank, result shows that most of respondents in the study area do not, with 85% percent of the respondents disagreeing to disposing materials into the septic tank. While the remaining 15 percent agreeing to the act. The presence of other materials can make the process of emptying the septic tank difficult, especially if the mechanised method is used.

Table 1 reveals that, the sources of wastewater into the septic tank majority (55%) have only wastewater from the toilet drained into their septic tanks which implies that the tank would largely store blackwater. This implies households predominantly release their sewage (greywater) outside the septic tank. Additionally, 45% revealed that they discharge their grey water into the septic tank. Implication of this is that the on-site system or containment would easily get filled up and require frequent evacuation compared to the counterparts without a combine system.

Table 1: Source of wastewater in septic tank

SOURCES	Frequency	Percentage (%)
Toilet only	33	55
Toilet, Bathing, Washing and Cleaning	27	45
Total	**60**	**100%**

By Table 2 results, most of the respondents opined discharging their other type of wastewater generated from cleaning and washing into open drain channel, while, 38% of them discharge their grey water unto open spaces available within and outside their residence. This information provides insight into disposal method of greywater in the study area as improper disposal, which can lead to environmental pollution, public health threats and loss of environmental aesthetics.

Table 2: Method of discharge of other type of wastewater

	Frequency	Percentage (%)
Open Drain channel	37	62
Open space	23	38
Total	**60**	**100%**

Figure 3 shows the actions undertaken and probably action to be taken by residents whenever the tank/pit get filled up. 92 percent posits that they empty the tank immediately it gets filled up while 8 percent will only empty the tank if given financial support. Regarding emptying frequency of septic tank, most respondents (55%) usually empty the septic tank when it gets filled up, while only 29 percent agreed to emptying their tanks in an interval of less than 5 years. This implies that majority of the residents do not really recall when or how often their tank gets filled up.

Figure 4 shows that majority of the respondents (45%) in Samaru stated that they are paid the amount of 15,000 Naira as charges for services of rendered by sewage service providers while 25% of them were charged the sum of 10,000 Naira for services rendered. Hence, the average sum of charged for services provided by the service providers as opined by respondents is 8,000 Naira.

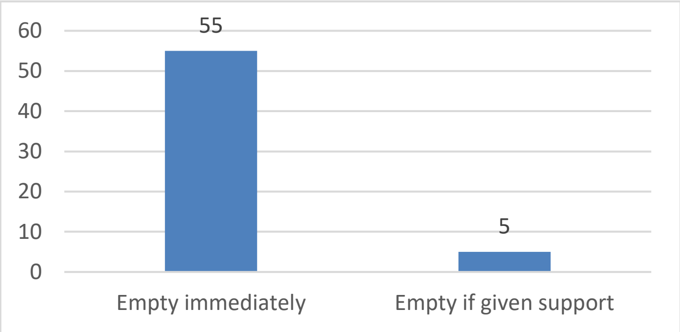


Figure 3: Action undertaken when the pit is full

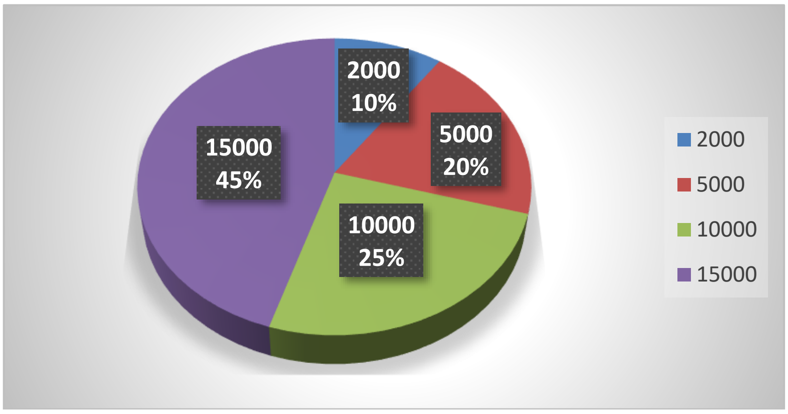


Figure 4: Amount paid for emptying services

Resident's perception on the operation of private sewage service providers

Figure 5 shows that majority of the respondents (77%) in the study area stated that they are satisfied with the overall services of private sewage service providers while only 23% were not satisfied with their services. Regarding satisfaction with fees charged, majority (77%) of the residents were satisfied. Therefore, it can be said that majority of the respondents can afford their service thereby been satisfied with the charges for the services provided.

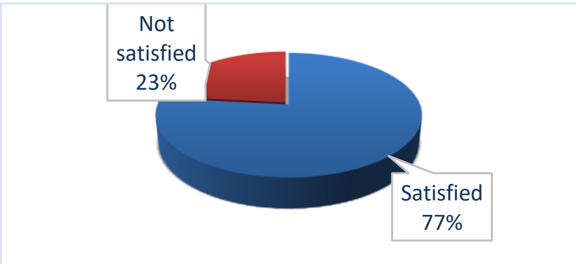


Figure 5: Satisfaction with services of PSSPs

Table 3 shows that (62%) of respondents are not willing to pay higher charges for private sewage management services while (22%) are willing to pay higher service charge for sewage management service. It suggests that majority of the household objected to increase in prices for more efficient sewage collection and management.

Table 3: Respondent's response to increase in price of charges

	Frequency	Percentage (%)
Agreed	13	22
Disagreed	37	62
Undecided	10	16
Total	**60**	**100%**

Key informant interview conducted with the private sewage service provider

From the physical (face-to-face) interview conducted with the commissioned private company providing sewage emptying and disposal services in Samaru, it was disclosed that the company solely renders sewage evacuation and emptying services from only septic tank/soak away excluding pit latrines. Faecal sludge in pit latrines was stated to be harder in composition therefore difficult to extract using the mechanised vacuum truck used by the company. The unit cost for evacuating a full truck load with the capacity of 9000 litres was stated to be 25,000 Naira (but sometimes negotiated down to 15,000 Naira by households). The capacity of the septic tank was said to determine the number of trips to be undertaken thereby determining the total cost for services.

Tasks engage in by the company when called upon by households include; location of the house and the septic tank within the house which is opened up by plumbers for access; use of herbicide and kerosine dissolvent of the faecal sludge in the tank/soakaway; connection of the vacuum truck hose into the pit and extraction of the sludge into the truck. After evacuation is complete, the septic tank is closed back and the waste transported for disposal. Evacuated wastewater was reported to be sold to interested farmers within 5-10 km of the evacuation location for a token of 5000 Naira (cost of diesel for transporting the waste). For Samaru neighbourhood, wastewater was sold to farmers in Shika. In a situation where there is no buyer, the wastewater was reported to be disposed into path of water runoff or tributaries flowing into the ABU dam in Samaru.

Constrains and challenges as reported include; disposal of foreign materials (pampers and sanitary pads) into septic tanks, poor constructed septic tanks which collapse during emptying process and poor accessibility to some of the households due to bad roads. The company owns only one mechanised vacuum truck (Plate 4) which is used for emptying and transportation of sewage usually maned by 4-5 personnel (driver, conductor and two or three other people).

Plate 4: Shirash Mechanised Vacuum Truck

CONCLUSIONS

In conclusion, it is observed that the sewage management practices of households in Zaria urban area is effective given the circumstances under review in the study area (Samaru) as majority of the residents have the sewage within their on-site systems evacuated which prevent the pollution of the underground water. Although the practices are not devoid of some issues that needs improvements such as disposal of untreated sewage into the environment and disposal of foreign materials into septic tanks by households. In addition to these issues, concerning the private sewage service providers and their practice in the study area; there is a huge potential to use and build upon the existing system addressing sewage management as most households have septic tanks, and stakeholders for collection and transport of faecal sludge already exist. Therefore, there is need for the coordination and organization of sewage management operations and enforcement of standards for the regulation and enforcement of environmentally safe collection, transport, treatment of sewage to strengthen and increase efficiency and effectiveness in operation of sewage management system, in other to achieve functional and healthy environment and to achieve the Sustainable Development Goal (6.2).

RECOMMENDATIONS

From the findings, there is need to make appropriate recommendations for effective implementation of a sewage management scheme in Zaria urban area.

1. Implementation of standards for the regulation and enforcement of environmentally safe collection, transport, treatment, and resource recovery or end use of all types of sludge are urgently needed.
2. There should be proper enlightenment by the necessary authorities to the residents of Zaria urban area about their roles and the dangers associated with indiscriminate wastewater disposal.
3. There should be adequate documentation and inspection of existing manual private sewage service providers operating in Zaria urban area by the authorities concerned to ensure safe, effective and efficient service delivery.
4. There should be collaboration between government agencies, private companies, community base organization, stakeholder and the residents in wastewater management.
5. Emptying of septic tanks should occur on a regular basis (e.g., 5 years), with a treatment facility located at distances that is reasonable for transportation.
6. Private sewage companies should adopt adequate treatment and safe disposal or resource recovery for the city-wide operations of wastewater management which are needed to provide adequate protection of human and environmental health.

REFERENCES

Abubakar, I. R. (2017). Household Response to Inadequate Sewerage and Garbage Collection Services in Abuja, Nigeria. Journal of Environmental and Public Health. pp, 1-11.

Bassan, M., Dao, N., Thuy, P., Hoai, A. V., Nguyen, V. A., & Strande, L. (2014). Initial Assessment of Sludge Management and Context in Five Cities: Son La, Lang Son, Hoa Binh, Bac Ninh, and Ba Ria. Partnership For Urban Resource Recovery (PURR).

Diop, B., & Mbéguéré, M. (2017). Dakar: organising the feacal sludge market. In I. Blackett, & P. Hawkins, FSM Innovation Case Studies: Case Studies on the Business, Policy and Technology of Faecal Sludge Management. Seattle, USA: Bill & Melinda Gates Foundation.

Ibiam, O. F., & Igewnyi, I. O. (2012). Sewage management and its benefits to man. International Research Journal of Biotechnology. 3(10), pp. 174-189.

Jeuland, M., Koné, D., & Strauss, M. (2004). Private Sector Management of Fecal Sludge: A Model for the Future? Focus on an innovative planning experience in Bamako, Mali. Duebendorf, Switzerland: Department for Water and Sanitation in Developing Countries (SANDEC).

Joseph, K. (2006). Stakeholder participation for sustainable waste management. Habitat International. pp, 863–871.

Mikhael, G., Robbins, D. M., Ramsay, J. E., & Mbéguéré, M. (2014). Methods and Means for Collection and Transport of Faecal Sludge. In L. Strande, M. Ronteltap, & D. Brdjanovic, Faecal Sludge Management: Systems Approach for Implementation and Operation (pp. 67-96). London: IWA Publishing.

Mukherjee, A., Arya, P., Dasgupta, S., & Chhabra, S. (2019). 'Bridging The Gap' Opportunities for private sector participation in Faecal Sludge and Septage Management. New Delhi: Centre for Policy Research.

Muxímpua, O., Hawkins, P., Stricker, J., Mugabe, Z., Matendjua, O., & Madamuge, A. (2017). Emerging lessons on FSM from Maputo, Mozambique. In I. Blackett, & P. Hawkins, FSM Innovation Case

Studies: Case Studies on the Business, Policy and Technology of Faecal Sludge Management. Seattle, USA: Bill & Melinda Gates Foundation.

Oji, I. S., Chukwuma, N. P., Friday, N. K., & Philip, P.-E. O. (2018). Domestic Wastewater Treatment and Reuse in Awka Urban, Anambra State, Nigeria. International Journal of Geography and Environmental Management. 4(2), pp. 16-24.

Scott, R., Scott, P., Hawkins, P., Blackett, I., Cotton, A., & Lerebours, A. (2019). Integrating Basic Urban Services for Better Sanitation Outcomes. Sustainability. 11(23), pp. 1-17.

UNEP. (2020). Faecal sludge management in Africa: Socioeconomic aspects and human and environmental health implications. United Nations Environmental Programme (UNEP).

Verhagen, J., & Ryan, P. (2008). Sanitation Services for the Urban Poor: Symposium Background Paper. IRC Symposium: Sanitation for The Urban Poor Partnerships and Governance. Delft, The Netherlands.

WHO/ UNICEF (2015). Joint Monitoring Program for Water Supply and Sanitation (JMP) update. Retrieved from ww.unwater.org

The Effect of Oil Spillage and Gas Pollution on Safety Health and Agricultural Production in Delta State

Adigwe, M. U. & Okah, C.M.
Correspondent Email: adigweuchechukwu@yahoo.com

Abstract

The Niger Delta region of Nigeria has been greatly affected by oil spillage with its devastating effects on the agricultural environment and the humans. It is on the note that the study examines the effect oil-spill pollution on agricultural production; safety and health of the people in the immediate environment. The study administered two set of questionnaires; one for the farmers in the areas and the second questionnaire was administered on resident doctors in selected areas through simple random sampling. The study analyzed 115 returned questionnaires from farmers and 20 returned questionnaires from resident doctors. Descriptive analysis using simple mean, relative important index and percentages was adopted for analysis. The study found that the effect of oil-spill pollution on health, safety and agricultural production is devastating as relative important indices for both effect health and agricultural production was 70% and above. It recommends that government must play a leading role by enforcing environment law which include the land use act, EIA decree and the petroleum and distribution act that will protect the oil producing communities as well as guarantee better livelihood of the affected communities.

Keywords: Oil Spillage, Pollution, Health, Agricultural Product, Environmental Law

1.0 Introduction

Since the industrial revolution, the discovery of crude oil has led to oil spillage through anthropogenic activities around the globe, affecting the earth's water, and landmass. Oil spillage has become a global issue (Kadafa, 2012). Oil spills can be divided into two groups, namely small oil spills and large oil spills. Small oil spills are more common than large oil spills, and can cause damage to the natural environment, especially in sensitive environments. Large oil spills, however, cause damage for a longer period of time, which can have environmental consequences for decades (National Oceanic Atmospheric Administration, 2020). The areas experiencing the most severe damage from oil spills are the oil producing areas. These areas face total destruction of the natural environment and ecosystems over time. One of these regions is the Niger Delta region of Nigeria, which is listed as one of the five most severely damaged ecosystems due to oil spillage in the World (Kadafa, 2012).

Crude oil is a fossil fuel located deep into the earth's crust. When crude oil is extracted, natural gas is released and when this natural gas cannot be utilized, gas flaring is used to dispose it off. In petroleum producing areas, such as the Niger Delta region, insufficient investments have been made to store or transport the gas, resulting in a high amount of gas flaring. Nigeria flares 17.2 billion m^3 of gas per year in collusion with the extraction of oil (Ajugwo, 2013). The knowledge of crude oil spill behaviour is of the utmost importance for the evaluation and risk assessment of mineral oil contamination and its effects. An oil spill can affect the environment in numerous ways. The magnitude of the impact could be dependent on the type of accident (blowouts, explosions, pipeline ruptures), the region of the spill and the clean-up and control techniques (Katusiime, 2009).

Oil spills have been reported over several decades in many parts of the world from Africa to North America. The Niger Delta region of Nigeria has been greatly affected by oil spillage with its devastating effects on the environment and the humans. Oil spills are common event in Nigeria (Baird, 2010). Half of oil spills occur due to pipe-line and tanker accidents (50%), other causes include sabotage (28%) and oil production operations (21%) with 1% of oil spills being accounted for by inadequate production equipment. High poverty level in the Niger Delta regions connected to the constant incidence of oil spills which has destroyed agricultural sources of income and productive activities in the region. Furthermore, Nnabuenyi (2012) observed the negative effects of oil spills on agriculture and lamented that most of the destroyed farmlands and polluted rivers have contributed to the frustration and lack of livelihoods for farmers and fishermen. Chindah and Braide (2000) indicated that oil spills cause great damage to Niger Delta communities due to the high retention time of oil in the soil occasioned by limited flow. This prevents proper soil aeration and affects soil temperature, structure, nutrient status and pH, and ultimately, crops are destroyed. The negative impacts on agricultural practices by oil extraction activities have contributed to the abject poverty and conditions of social deprivation experienced by communities in the region (Effiong *et al*., 2012).

2.0 Literature Review

The environment is a major determinant of health. Human health is influenced by physical exposure, biological and chemical risk factors. Because of permanent interaction between human and environment, our health is to a considerable extent determined by environmental quality. The World Health Organization defines health as a state of complete mental, physical and social wellbeing (WHO, 2023). Irhivben and Omonona, (2013) indicated that toxic chemicals at low concentrations will not immediately kill humans, however, depending on their potential to bio-concentrate when climbing the food chain. Persistent chemicals may create a human hazard in case of chronic ingestion.

Oil exploration, exploitation and use have several consequences for the environment. Oil pollution is one of the major problems faced by coastal ecosystems. Oil pollution can be described as the introduction by man directly or indirectly any hydrocarbon materials especially crude oil and its refined products into the environment (Adeyanju, 2004). The Nigerian physical environment has been negatively impacted by the activities of oil companies. Oil pollution which arises mainly from oil spills has serious implication for bio-diversity as most biotic habitats are either destroyed or altered making them unsuitable for habitation. The overall effects of oil on ecosystem health and biota are numerous. Oil interferes with the functioning of various organs and systems of plants and animals. It creates environmental conditions unfavourable for life. For example, oil in the water surface forms a layer which prevents oxygen from dissolving in water. Crude oil also contains toxic components which cause outright mortality of plants and animals as well as other sub lethal impacts (Osuji, Erondu and Oguli, 2010). According to Ekpebu and Ukpong (2013), oil spillage has become a great menace to the environment causing land degradation, air and water pollution; killing fishes and other seafood (Nnabuenyi 2012 and Chindah and Braide, 2000). Furthermore, the emission of hazardous gases into the environment and the unsafe use of pesticides in agricultural systems usually cause natural disasters such as desertification and flood. It is therefore imperative to solve the problem.

In one study by Ekanem and Nwachukwu (2015), it was noted that the River state had lost more than 20% of its habitable land to oil spills Ugwuanyi *et al.* (2012) in their study reported that with the discovery and subsequent exploration of crude oil in 1956 in River State, the environmental pollution emanating from such exploration has led to unprecedented economic deprivation and underdevelopment of the area. As an open ticket to destroy the land, laws were made such as the Petroleum Act of 1969 and land use decree/Act of 1978 that regulates community access to communal land while at the same time making it possible for the multinational investors to have unrestricted access to explore oil unchallenged even on sacred lands (Achi, 2003). With the unrestricted access for oil exploration, the activities involved has since created many problems for both the inhabitants and the environment rather than the initial thought of revenue generation. Particularly, farmland has been severely polluted resulting in the decline of soil and marine resources, and a subsequent decrease in agricultural output (Ugwuanyi *et al.*, 2012).

Activities such as drill cutting, barites and bentonite clays dumped on the ground prevent plant growth. Opara (2003) and (Nwankwo *et al.*, 2011) reported that the ecological devastation due to oil exploration had rendered farming and fishing unproductive, while pollution and continuous flaring of gas have created health hazards and rendered fishing and farming activities almost impossible. Katusiime (2009) in her report on Niger Delta said that leaking pipelines running through villages, farms, creeks and rivers are a major source of pollution. Farmland polluted by oil is rarely rehabilitated thereby causing economic ruin. Platform (2006) in its report on oil pollution in the Niger Delta stated that between 1976 and 1998, over 2.5 million barrels of oil have been spilt into the environment and that these spillages are a regular feature of life in the Niger Delta.

Ani *et al*., (2015) in a study on the effect of oil spill on crop production in the Niger Delta, reported that oil spill on crops causes great damage to the plant community due to high retention time of oil occasioned by limited flow. The oil hamper proper soil aeration as oil fi lm on the soil surface acts as a physical barrier between air and the soil. In fact, oil pollution affects the physicochemical properties of the soil such as temperature, structure, nutrient status and pH. Oiled shoots of crops like pepper and tomatoes may wilt and die off due to blockage of stomata thereby inhibiting photosynthesis, transpiration and respiration. In fact, germination, growth performance and yield of these crops stifled by oil spillage (Irhivben & Omonona, 2013)

In the same vein, communities oil spills have posed a major threat to the environment which has led to total annihilation of the ecosystem thus life in this area is becoming increasingly unbearable due to the ugly effects of oil spills (Oyem 2011). Intermittent oil spillage has rendered vast stretch of indigenous farmlands useless therefore as important as oil might seem to the nation's economy; the people perceive the discovery of oil as threat to their life support system (the land).This particular oil spill has a serious impact on the vegetation and wildlife to the extent that plants could no longer bear its traditional faults and those making a living from the sea resources were stranded, thus in most cases such damage is temporary and is caused primarily by the physical properties of oil creating nuisance and hazardous conditions. The broad aim of this study is to "analyze the effects of oil spillage/pollution on agricultural production in Delta Central Agricultural Zone, of Delta State". Identify agricultural production activities of the respondents. Identify causes of oil spillage/pollution of the area; describe the effect of oil spillage/pollution in agricultural production activities and effect of oil spill pollution of human health.

Table 35: Causes of Oil Spillage And Its Effects

Year	Location	**Cause of spill**	**Effect**
1979	Forcados Terminal	Accidental rupture of the bottom plate of storage tanks	Fishing activities inhibited, mangrove destroyed
1980	Funiwa oil well blow out	Oil well blows out	Death of fishes, crabs etc. Socio economic activities affected.
1980	Oyakama	Oil well blows out	Over 25 hectares of land polluted.
1981	Abudu Pipeline	Pay loader destroyed Pipeline	Damage to agricultural products, water, soil and marine line.
1983	Pipeline rupture	Pipeline rupture	Fishes killed, water contaminated.
1986	Funiwa oil Blowout	Oil well blows out	About 350 hectares of mangrove polluted; fish killed.
1994	Agoda/Brass oil pipeline	Pipeline corrosion	Over 10sq km of farmland polluted, ponds, lakes and stream contaminated.
1998	Idoho (Mobil)	Offshore discharge	Over 10sq km of farmland polluted, ponds, lakes and stream contaminated.
2003	Kwale oil well explosion	Lack of maintenance of facilities suspected	Farmland polluted.
2003	Kalabilema oil spill explosion	Oil spill and explosion followed causes not yet ascertained.	Five lives lost

Source: Oyem, 2011

3.0 Methodology

Five Local Government Areas (LGAs) including Isoko South, Isoko North, Ughelli South, Ughelli North and Udu which are home to several oil producing communities is the area of study; and it's a leading source of on-shore crude oil production in Delta State. Delta State lies approximately between longitude 5 0 00′ E and 6 0 45′E of the Greenwich Meridian, and latitude 5 0 00′N and 6 0 30′ N of the Equator. It is one of Nigeria's extremely southern states, and covers an area of 17,001 km square. The inhabitants of communities in this area are mainly

Table 36: Effect of Spilled Petroleum Products on Human Health

Petroleum Product	Source	Effects
Benzene	Oil, Coal, Natural Gas	Carcinogenic •Causes leukemia, breast and urinary tract cancer. • It reduces red and white blood cell pro-duction in bone mar-row. • Decreases function of T-cell and B-cells. • Causes chromosome aberration.
Sulfur Dioxide	Oil, Coal, Natural Gas	Causes lung cancer and other pulmonary diseases. • Causes asthma and heart diseases.
Formaldehyde	Natural Gas	Carcinogenic • Causes leukemia and nasopharyngeal can-cer. • Causes genotoxicity and infertility
Polycyclic Aromatic Hydrocarbons (PAH)	Oil and Coal	Carcinogenic and ge-netic mutagenic • Exposure linked to childhood asthma, low birth weight and DNA damage.
Hydrofluoric Acid	Oil and gas	Damage lungs leading to chronic lung diseas-es.

Source: Osuji, Erondu and Oguli, (2010)

crop farmers, and cases of incessant oil spillages have been reported there. Primary data was used for the study, total number 24 registered farmers were randomly selected across each five local government and a cross-sectional survey was employed through a structured questionnaire. A total of 120 farmers formed the sample name but only 115 copies of respondents' questionnaires were useful for analysis. The two main sources of data used for this study was primary. The study also selects 20 (twenty) medical practitioners to give the health implication of oil spill and gas pollution across the five local governments. The primary data was collected from the field survey using questionnaire.

4.0 Result and Discussions

Table 3 shows that 43.5% of the respondents are between the age brackets of 51 – 60 years. They are followed by 29.6% of the respondents who are between the ages of 41- 50 years, while 17.4% and 14.8% of the respondents are over 60years and between 31-40 years. The mean age from the distribution is 41.8 years this implies that the respondents had been in agricultural production for a long time and must have had experiences on the effects of oil spillage/pollution. Table 1 also shows that 65.2% are males, while 34.8% of the respondents are females. This implies that majority of males in the study area are involve in agricultural production than the female because they are heads of families. Furthermore, 69.9% of the respondents are married, 15.6% are divorced, while 10.4% are widows. This implies that majority of people who are involved in agricultural production are married. The table shows that 53.9% of the respondents have secondary education, followed by 11.0% that have primary education, 14.8% has tertiary education, while 34.8% of the respondent have no formal education. This result revealed that majority had formal education, hence could read and write.

Table 4 shows the agricultural production activities of the respondents, the table shows that 78.3% of the respondents engage in cassava production, followed by 88.7% engaged in fish production, 85.2% engage in yam production, 30.4% engage in cocoyam production, 30.4% are engaged in agricultural business, 26.1% are both engaged in poultry production and Goat rearing and while, 22.6% of the respondents are engage in sheep rearing. The meaning is that the respondents are farmers.

Table 37: Demographic information of respondent

Demographic Information		Frequency	Percentage
Age	18-30	0	0
	31-40	20	17.4
	41-50	50	43.5
	51-60	34	29.6
	61 and above	17	14.4
	Total	115	100
Married status	Married	80	69.6
	Divorced	18	15.6
	Widow	17	14.8
	Total	115	100
Education	Primary	13	11.3
	Secondary	62	53.9
	Tertiary	40	34.8
	Total	115	100
Gender	Male	75	65.2
	Female	40	34.8
	Total	115	100

Table 38: Nature of Agricultural Production Activities

Nature of activities	Frequency	Percentage
Yam production	90	78.3
cocoyam processing	50	30.4
Agric business	35	30.4
poultry production	30	26.1
cassaava production	108	94
sheep rearing	26	22.6
fish production	26	88.7
goat rearing	30	26.1

Table 5 shows the causes of oil spillage/pollution on agricultural production by the respondents. It shows that 95.7% of respondents agree to both explosion of oil wells/terminal/stations and corrosion of oil pipelines as causes to oil spillage/pollution on agricultural production, followed by 86.9% of the respondents agree to drilling of oil wells as cause, 82.6% of the respondents agree for spills from vandalized oil pipelines, leakage from oil tanks/faulty facility and spills from loading oil vessels as causes, 80.0% of the respondents agree to maintenance activities of oil companies as cause, 74.8% of the respondents agree to natural gas flaring as cause while 67.8% of the respondents agree to sabotage as one of the causes of oil spillage/pollution on agricultural production. The above is in line with Oyem (2011) who posited that thousands of barrels of oil have been let loose into the environment through corrosion of oil pipeline and explosion of oil well in the country.

Table 39: Causes of Oil Spillage/ Pollution in the Study Area

Causes of spill	frequency	percentages
Explosion of oil wells/terminal stations	110	95.7
Spills from vandalized oil pipelines	100	86.9
Leakages from oil tanks/faulty facility	95	82.6
Corrosion of oil pipelines	108	94
Spills from loading oil vessels	95	82
Maintenance activities of oil companies	92	80
Natural gas flaring	92	80
Sabotage	86	74.8

The analysis of the effect of oil-spill pollution across the study area is presented in Table 6. The respondents asked to indicate their level of agreement toward the subject matter such as strongly agree-5, agree-4, indifferent-3 disagree-2 and strongly disagree-1. The result is presented in mean and relative important index (RII) in percentage. The result indicated that effect of oil spill pollution having 80% and above is said to have been strongly agreed by the respondent such as Poor soil aeration of farm land; Degradation of farm land; Destruction of soil micro-organisms; Destruction of soil structure; Crop failure; Poor yield of crop and Rotting tubers. Furthermore, effects of oil-spill pollution having 70 and 79%, is said to have been agreed with by the respondent such as Increased soil temperature/toxicity; Low land productivity; Yellowing of crop leaves; Stunted growth of crop; Wilting of crops; Toxicity water available for livestock; Death of fishes and aquatic life; Contamination of water/river sources; Crop leaves appear burnt; Bad taste of produce; Outbreak of crop disease and Death of livestock. Therefore, the result revealed that all the effects of oil-spill pollution maintained high relative important index which indicates that the effects of oil-spill pollution considered or the study were strongly agreed with by the respondents in the study areas.

Table 40: Analysis of effect of Oil-spill pollution across the study Area

Effect of oil spill on Agricultural production	N	Mean	RII (%)
Poor soil aeration of farm land	115	4.11	82.2
Degradation of farm land	115	4.12	82.4
Increased soil temperature/toxicity	115	3.5	70.0
Destruction of soil micro-organisms	115	4.21	84.2
Destruction of soil structure	115	4.01	80.2
Low land productivity	115	3.51	70.2
Yellowing of crop leaves	115	3.9	78.0
Stunted growth of crop	115	3.55	71.0
Crop failure	115	4.07	81.4
Poor yield of crop	115	4.33	86.6
Rotting tubers	115	4.21	84.2
Wilting of crops	115	3.66	73.2
Toxicity water available for livestock	115	3.88	77.6
Death of fishes and aquatic life	115	3.56	71.2
Contamination of water/river sources	115	3.5	70
Crop leaves appear burnt	115	3.53	70.6
Bad taste of produce	115	3.6	72.0
Outbreak of crop disease	115	3.99	79.8
Death of livestock	115	3.78	75.6

The result demographic information of resident doctors across the five selected local governments is presented in Table 5. 75% majority of respondents fall between 41-50years and 25% fell between 51-60years. 100% of sampled doctors were married and 100% resident doctors had university degree. The implication of this is that the study sampled young active doctors who are up to date in health implication of oil spill pollution.

The effect of petroleum product around the spill area human health is presented in Table 8. The respondents asked to indicate their level of agreement toward the subject matter such as strongly agree-5, agree-4, indifferent-3 disagree-2 and strongly disagree-1. The health effect of benzene had relative important index (RII) of 88.2%. The effect of sulfur dioxide on human health had relative important index 94.2%, health effect of formaldehyde had relative important index of 86.8% and the health effect of polycyclic aromatic hydrocarbons on human health had relative important index at 84.4% while health effect of Hydrofluoric Acid on human health had relative important index of 95.4. this indicates that all the responses maintained very high level to the negative effect of oil-spill product.

Table 41: Demographic Information of Sampled Resident Doctor

Demographic Information		Frequency	Percentage
Age	18-30	0	
	31-40	0	
	41-50	15	75
	51-60	5	25
	61 and above		
	Total	20	100
Married status	Married	20	100
	Divorced		
	Widow		
	Total	20	100
Education	Primary		
	Secondary		
	Tertiary	20	100
	Total	20	100
Gender	Male	17	85
	Female	3	15
	Total	20	100

Table 42: Effect of petroleum product across the selected areas

Product	Effect of petroleum product	N	Mean	Overall Mean	RII (%)
Benzene	Causes leukemia, breast and urinary tract cancer.	20	4.60	4.41	88.2
	It reduces red and white blood cell pro-duction in bone mar-row	20	4.55		
	Decreases function of T-cell and B-cells	20	4.50		
	Causes chromosome aberration	20	4.00		
Sulfur Dioxide	Causes lung cancer and other pulmonary diseases	20	4.77	4.71	94.2
	Causes asthma and heart diseases	20	4.65		
Formaldehyde	Causes leukemia and nasopharyngeal cancer.	20	4.66	4.34	86.8
	Causes genotoxicity and infertility	20	4.02		
Polycyclic Aromatic Hydrocarbons (PAH)	Carcinogenic and genetic mutagenic	20	4.00	4.22	84.4
	Exposure linked to childhood asthma, low birth weight and DNA damage.	20	4.44		
Hydrofluoric Acid	Damage lungs leading to chronic lung diseases.	20	4.77	4.77	95.4

5.0 Conclusion and Recommendations

The causes of the oil-spill pollution are drilling of oil wells, explosion of oil wells, spills from vandalized oil pipelines, leakages from oil tanks/faulty facility, corrosion of oil pipelines, spills from loading oil vessels, maintenance activities of oil companies, natural causes, flaring, sabotage. The effects of oil spills pollution includes reduction of soil fertility, poor soil creation of farm land, degradation of farm land, increased soil temperature/toxicity, destruction of soil micro-organisms, destruction of soil structure, low land productivity, yellowing of crop leaves, stunted growth of crop, crop failure poor yield of crop, rotting tubers wilting of crop, toxicity water available for livestock, deaths of fishes, contamination of water/river sources, crop leaves appear burnt, bad taste of produce, outbreak of crop disease death of livestock. Also, the health implication of oil-spill pollution has been found disastrous at it impacted negatively on the human health that affect the livelihood of residents of oil spill areas. The study recommends that government should establish a permanent disaster management institution in this area as none has existed there previously. The oil companies should engage in preventative measures to mitigate or minimize the risk of oil spillage like investing the adequate and regular maintenances of their oil installations and the replacing of old pipes, as well as improving the security agencies guarding their various installations (to prevent the vandalization of pipelines). Government must play a leading role by enacting and enforcing environment law which include the load use act, EIA decree and the petroleum and Distribution act that will protect the oil producing communities as well as guarantee the affected communities of a better livelihood.

Reference

Achi, C. (2003), Hydrocarbon Exploitation, Environmental Degradation and Poverty. Niger Delta Experience in Proceeding of the Diffuse Pollution Conference, Dublin, 1(5): 249-255.

Adeyanju, J.A. (2004). Government and the oil pollution crisis in Nigeria. *International Journal of Environmental Issues* 2(2): 217-227.

Agricultural Zone of Delta State Nigeria. *International Journal of Environmental Sciences Vol. 4 No. 2. 2015. Pp. 75-80*

Ani, A.O., Chikaire, J.U., Ogueri, E.I. and Orusha, J.O. (2015) Effects of Oil Spillage (Pollution) on Agricultural Production in Delta Central

Baird, J. (2010). "Oil's Shame in Africa". African J. Biotechnology. 8 (11): 2535 - 2540.

Chindah A.C., Braide S.A., The Impact of Oil Spills on the Ecology and Economy of the Niger Delta". In Proceedings of the Workshop on Sustainable Remediation Development Technology held at the Institute of Pollution Studies, Rivers State University of Science and Technology, Port Harcourt, 2000.

Ekanem, J. and Nwachukwu, I. (2015). Sustainable Agricultural Production: Degraded Oil Producing and Conflict Prone Communities of Niger Delta. *A Journal of Agriculture and Sustainability*, 8 (1), 110 - 120.

Irhivben, B.O. and Omonona, B.T. (2013) on Implication of oil exploration on Agricultural production" International Journal of Humanities and social science invention, ISSN (online): 2319 – 7722, ISSN (Print): 2319 – 7714. www.Ijhssi.org Volume 2 Issue 4/April. 2013/PP.59-63.

Katusiime, D., 2009. Like oil our environment is equally very important. African Institute for Energy Governance, Kampala, Uganda. www.Afriegoug. org/index.php?option-com...task...Afriego. Newsletter Issue 1, p. 37 (Accessed 12/08/2009)

Nnabuenyi, U.M. (2012). Impact of Oil Exploration and Exploitation on the Niger Delta Region: Environmental Perspective. In: Akpotor, A.S., Egboh, S.H., Ohwona, A.I., Orubu, C.O., Olabaniyi, S.B.and Olomo, R.O., Editors. *Five Decades of Oil Production in Nigeria: Impact on the Niger Delta*, Centre for Environmental and Niger Delta Studies, Ibadan.

Nwankwo, C.; Ogagarue, D. (2011). Effects of Gas Flaring on Surface and Ground Waters in Delta State Nigeria. *J. Geol. Min. Res. 3:* 131–136

Osuji, L.C., Erondu, E. S. & Oguli, R.E. (2010). Upstream gasoline degradation of mangroves and intertidal shores: The Niger Delta Experience. *Chemistry and Biodiversity* 7:116-128.

Ugwuanyi, C. A., Garbu, A. and Makarau, S. B. (2012). Impacts of Environmental Pollution on Agricultural Productivity in the Niger Delta. *Journal of Environmental Science and Resources Management.* 4: September 2012.

World Health Organization (1948). Constitution of the World health Organisation. Geneva: World Health Organization.

Residential Location Choice: A Study of Household Preferences in Minna, Niger State, Nigeria

Santali, B.N.
Department of Urban and Regional Planning, Federal University of Technology, Minna, Niger State
Corresponding Email: olaide.akande@futminna.edu.ng

Abstract

Planners and policymakers are becoming more concerned with how to quantify the factors that affect households' decisions about where to live among Minna people as a result of concerns about the quality of urban life in cities. The study therefore examines the factors that determine resident's choice of location in Minna, from the perspective of residential densities. In achieving this, the research methodology adopted Multistage sampling technique for cluster sampling. Simple Random Sampling was then used in each cluster for the administration of 588 questionnaires in the study area in order to assess the various attributes in choice of location. The data obtained was analysed using the Statistical Package for Social Science (SPSS) and MS Excel, thereafter, the results were presented in tables. The study therefore established that residential density and attribute of households is a critical factor that influence the Residential Location Choice (RLC) of households. Households residing in high density neighbourhoods pay more attention to economic (3.98) and transport (3.80) factors, while households in low density neighbourhoods do not consider economic (2.23) and transport (2.37) factor as a significant factor in RLC. The study also revealed that there is no significant relationship between the three residential densities regarding factors influencing RLC. The study therefore concludes that factors influencing RLC is not generic in space and hence can be affected by neighbourhood density and income levels of households.

Keywords: Residential, Location, Choice, Neighbourhood, Neighbourhood Density.

Introduction

Sustainable Development Goals (SDGs) eleven (11) places a focus on creating inclusive, secure, resilient, and sustainable cities and human settlements. Furthermore, according to the urban residential location theory, tenants' residential preferences are influenced by the proximity to urban amenities, the availability of public transportation, and the associated expenses of commuting and lodging (Prashker *et al*., 2008). However, the complexity of people's lives makes choice of location a decision that is influenced by a variety of factors such as physical and environmental factors, facilities and services, public security, and community/socio-economic factors (Beamish, Goss and Emmel, 2001).

Location choice study is interdisciplinary in nature. The reasons behind and effects of people's spatial mobility are of interest to sociologists, economists, demographers, regional scientists, urban planners, and other professionals. Different decision-making methods for selecting a residential site have arisen. The Geographic Model, which emphasises spatial factors like distance, is one of them. Alonso (1964), Kain and Quigley (1970), and Evans (1973) all claim that people frequently consider the marginal cost of moving closer to the CBD, even though this cost ought to be comparable to the CBD's marginal gain.

Rapid urbanisation has created serious housing issues, including overcrowding in suboptimal homes, the creation of slums and shanties, and a scenario where 60% of Nigerians can be considered "houseless citizens" (FGN, 2004). Although the country's various governments have made efforts to create a liveable urban environment by, among other things, building accessible roads, affordable housing, creating policies that benefit both homeowners and tenants, lowering the cost of construction materials, and supplying social amenities. However, finding a home of one's choice remains a difficult endeavour in spite of all these efforts because the mechanisms offered to check the limits are ineffective.

Minna has continued to draw immigrants from all across the nation, in large part because of its advantageous location as a gateway between the northern and southern regions of the nation. For instance, the population of Minna has continued to grow from about 200,000 in 2006 (NPC, 2006) to over 400, 000 people today (NBS, 2021). The late 1990s religious' unrest in the country's north (Ahmed, 2005) and more recent insurgency activity in some northern Nigerian regions including Niger State have both contributed to the city's rapid population growth. Due to the city's rapid population increase, there are not enough suitable housing units available (Ibrahim, Adetona and Olawoyin, 2014). One of the issues brought on by Minna's high rate of immigration is the difficulty inhabitants have finding reasonably priced, good, and decent housing.

Several scholarly works (Nkeki and Erimona's, 2018; Jin and Lee's, 2018; Sinniah *et al.*, 2016) have been carried out on residential location choice both in developed and developing countries. However, majority of these studies accounted for various factors without paying attention to the spatial dynamics within the study area. The spatial diversification of where households reside plays significant role in their housing decision. Hence, it is imperative to disaggregate the opinion of households from different spatial unit, particularly, different neighbourhood densities. This study is therefore an attempt to understand the factors responsible for residential location choice with cognizance to the neighbourhood densities in Minna, Niger State. The choice of a family's primary residence is a concern that transcends municipal boundaries. Numerous research on household residential site preferences have been conducted in both developed and developing nations. Notably, these studies did not concentrate on the density of residential areas or neighbourhoods, which is why the current study was conducted.

The Study Area

Minna is a city in the north central region of Nigeria, it is the capital of Niger State, one of Nigeria's 36 federal states, and is the headquarters of Chanchaga Local Government Area with an estimated population of 201,429 people (2006 census) making it the biggest city in Niger State. As the administrative capital of Niger State, Nigeria, Minna, is situated on 243 metres above sea level at 9 62"N latitude and 6 55"E longitude. With a population of 201,429 according to the 2006 census, Minna is the largest city in Niger State and the capital of Niger State, one of Nigeria's 36 federal states. Minna also serves as the administrative centre for Chanchaga Local Government Area. The town has increased in size from its initial population of 202151 as of the 2006 Census due to the ongoing influx of people into the state capital. Minna was initially confined to Chanchaga LGA, However, over the years the city (Minna) has grown into the adjoining LGA of Bosso.

Literature Review

Concept of residential location choice

The specific home or apartment that a family chooses is referred to as its residential location (Sanit et al 2016). Residential choice is the process by which households choose where to reside and, when dissatisfied with their current residence, determine when and where to move (Poku-Boansi and Adarkwa, 2016). Giuliani (2004) claims that deciding on where to live entails conducting an assessment in which the ideal environment's requirements are weighed against the available options. An increasing number of urban residents are forced to choose the best place to live.

Determinants of household residential location choice

According to the literature, neither one specific factor nor the availability of certain local services affects household location selections. When a household choose where to live or stay, a variety of considerations are taken into account. The majority of studies on residential location choice in the pertinent literature are concerned with accessibility and transportation options, amenities, facilities, and features of the home environment, attachment to the neighbourhood, and the social, economic, and demographic characteristics of the people living there.

According to studies, residents' location choices seem to be primarily influenced by proximity to the city centre or their place of employment, as well as the quality and variety of local transit options. Based on their preferred modes of transportation, households and individuals situate themselves.

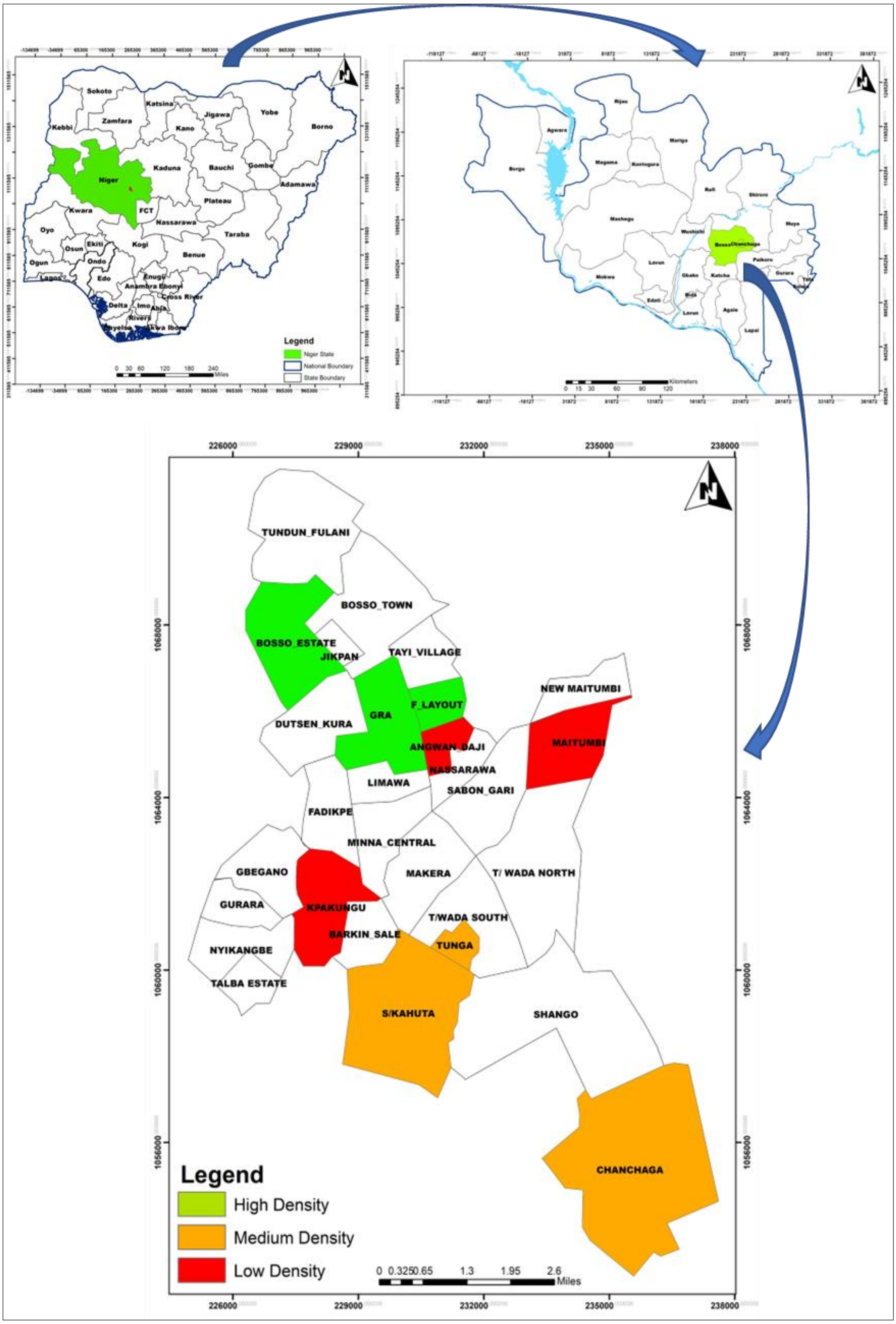


Figure 1: Map of Minna showing the Selected Neighbourhoods

Access to public transportation, ease of cycling or walking, low levels of traffic, and pedestrian friendliness are residential choice criteria characterised as travel behaviour and supportive of public transportation, according to Sinniah *et al* (2016).'s study on residential location preferences. Wu (2006) discovered that factors like safety, closeness to the city, accessibility to public transportation, ease of travel to and from the workplace, sense of safety, and access to medical and educational facilities all affect where people choose to live.

Studies that examine how transportation issues affect where households live have produced a variety of conclusions. While some academics believe that transport variables are significant in determining where a household chooses to live, others believe that the high level of accessibility provided by private vehicles in metropolitan regions lessens the significance of transport factors.

Guiliano and Small (1993) discovered that households typically commute more than they need to in a study of commuting behaviour and residential location in Los Angeles, US. This shows that transportation, at least to the workplace, is not a significant driver of residential location. Transport variables, on the other hand, were discovered to be significant predictors of home movement and location choice in a more recent stated preference experiment conducted in Oxfordshire, UK. According to the study, an increase in the amount of time or money needed to commute to work or shop was a good indicator of family movement, or a "push factor." "People choose residential areas with a mix of shorter commuting times, cheaper transit expenses, lower density, and higher school quality," the scientists wrote in their conclusion (Kim and others, 2005).

Demographics are a significant factor in determining residential location preference (Givliamo and Small, 1991). A key factor in deciding where to live is the family or household cycle stage. Hazel and Moon (2009) argued that older age groups have less residence mobility than younger age groups do. Another element influencing selection for a place to live is income. This aspect of housing selection has drawn a lot of attention from scholars. According to Okesoto et al. (2014), there is a weaker association between income and housing price than there is between income and housing affordability. They come to the conclusion that there is no housing income elasticity.

According to Jin and Lee's (2018) Urbanism model, different income and age groups have distinct preferences for various aspects of residential site. They also stress the existence of residential segregation based on income in the case of Korea. According to a survey by Petkar and Macwan (2018), residential preference varies depending on personal preferences, family size, and economic level. That according Hensher (2001), households with higher incomes, kids, or two workers exhibit various home consumption patterns.

According to literature, social standing and relationships play a significant role in determining where a household resides. Social networks and social ties have been proposed as measures of social capital that are crucial for urban people to successfully navigate daily life in cities. Social capital is defined in the urban livelihoods' paradigm as the networks of interpersonal support that exist inside and across households, extended families, and communities. People can use these networks to get housing as well as information about jobs and opportunities (Meikle, 2002).

Social connections, however less generalizable than other criteria, can play a significant role in a minority group's decision over where to live in a city. According to research by Guo and Bhat (2007), households in the United States "tend to locate in an area with a large proportion of other households with a similar household structure and household size as their own (Sinniah *et al.,* 2016). Also mentioned was how having a car significantly reduces the importance of distance when deciding where to live. A person's sense of belonging in their environment has a significant impact on their level of contentment. When deciding where to live, it's crucial to be close to family, friends, relatives, or other social groupings, as well as to neighbours who share your values and socioeconomic position.

Fejiten et al. (2008) referred to the problem as "social space" and stressed the value of the depth of social networks in determining the best living situation. Although they are determined to be somewhat less relevant than other factors, social relations, described as "community preferences" in Petkar and

Macwan, are offered as one of the factors that govern residential preference. Winstanley et al. (2002) demonstrated how familiarity and social relationships affect residential location choice in a study on residential mobility. They asserted that a lot of people find it difficult to leave comfortable environments to which they have grown used and attached. The cost of housing is a big role in where a household decides to live because most households make housing decisions based on their budgets. According to a significant Australian study, housing affordability has a significant role in determining where families choose to live. This, along with the desire to become homeowners, is one reason why people have relocated to the urban periphery (Burgess and Skeltys, 1992).

Researchers from Africa have also explored the theories underlying residential location preferences. According to a study by Acheampong and Anokye (2013) in Ghana, the most significant explanatory factors for RLC in two of Kumasi's peri-urban communities are family relationships, closeness to the workplace, relatively low land prices, and house rentals. According to the study, housing characteristics relating to the neighbourhood are much less essential than socio-cultural, housing, and accessibility concerns. In a similar vein, Nkeki and Erimona's (2018) findings discussed how socio-cultural cohesiveness and accessibility played a major part in influencing household decision-making over where to live in Benin City, Nigeria.

Choice of a family's primary residence is a concern that transcends municipal boundaries. Numerous research on household residential site preferences have been conducted in both developed and developing nations. Notably, these studies did not concentrate on the density of residential areas or neighbourhoods, which is why the current study was conducted.

Methodology

A combination of primary and secondary data sets was used in the investigation. The main information relates to the elements that influence where people choose to live. Specifically, the physical, social, economic, and environmental aspects that affect where people choose to live. The literature on the topic from different writers is included in the secondary data. Since the "household" is the unit of measurement for the study, the estimated number of households is 27,613. Sallant and Dillmann's (1994) sample size formula was used to calculate the study's sample size, which came to 588 with a 4% confidence interval. Using a multistage sample (Cluster sample and Simple random) strategy, 588 questionnaires were distributed and returned completed. Using low, medium, and high residential densities, Minna was classified into clusters of low, medium and high-density neighbourhoods. Three neighbourhoods were randomly chosen in each cluster; hence, a total of nine (9) neighbourhoods were selected for the study. Consequently, the respondents for the study were chosen using a simple random procedure. Kpakungu, Angwan Daji and Maitumbi were selected for high density neighbourhoods, Sauka Kahuta, Chanchaga, and Tunga from medium density neighbourhoods, while GRA, F-Layout and Bosso Estate were selected as low-density neighbourhoods. The data collected was analysed using descriptive (Percentage and Mean) and inferential (Pearson Product Moment Correlation) statistic

Results And Discussion

Residential Location Choice in High Density Neighbourhoods in Minna

The factors that influence residential location choice of households residing in high density residential in Minna were assessed and the result is presented in Table 1. The result shows that economic factor (3.98) is the most significant factor that influence the RLC of households in the high-density neighbourhoods, including transport factor (3.80), security (3.20), and physical factor (3.15). Social factor (2.50) and infrastructure and amenities were not significant drivers of RLC in high density neighbourhoods in Minna. This invariably shows that households in density neighbourhoods in Minna pay less attention to social factors and infrastructure when making decisions on residential location, rather they are concerned about the economic implication and access to transport or mobility.

Table 1: Factors Influencing RLC in High Density Neighbourhood of Minna

Factors	Sum	Mean	Decision
Physical factor (Housing)	1852	3.15	Significant
Infrastructure and Amenities	1664	2.83	Not Significant
Security	1880	3.20	Significant
Social Factor	1467	2.50	Not Significant
Economic Factor	2339	3.98	Significant
Transport Factor	2236	3.80	Significant

Residential Location Choice in Medium-Density Neighbourhoods in Minna

The drivers of RLC in medium density neighbourhoods in Minna is presented in Table 2. Households in medium-density neighbourhoods in Minna pay significant attention to all the factors considered in this study. Table 2, shows that economic factor was the primary driver with a mean of 3.82, followed by security factor (3.77), infrastructure and amenities (3.51) and physical factor (3.45). Although, transport and social factor were the least rated factors, they were significantly considered when deciding the household's choice of neighbourhoods. These shows that households in the medium-density neighbourhoods pay more attention to several factors when making decision for the choice of residential neighbourhoods as against the attitude of households in the high-density neighbourhoods with less consideration for social and infrastructure factors.

Table 2: Factors Influencing RLC in Medium-Density Neighbourhood of Minna

Factors	Sum	Mean	Decision
Physical factor (Housing)	2029	3.45	Significant
Infrastructure and Amenities	2217	3.51	Significant
Security	2064	3.77	Significant
Social Factor	1887	3.21	Significant
Economic Factor	2246	3.82	Significant
Transport Factor	1882	3.20	Significant

Residential Location Choice in Low-Density Neighbourhoods in Minna

Table 3 shows the drivers of residential location choice in low density neighbourhoods in Minna. The result revealed that contrary to what was reported in high-density neighbourhoods, economic (2.23) and transport (2.37) factors are not significant factors considered for RLC among households in the low-density neighbourhoods. The primary factor considered by households in the low-density neighbourhoods are security (4.19), social factor (3.89), physical factor (3.86) and infrastructure (3.51). Households in low density neighbourhoods otherwise referred to as high income earners play down the issue of transportation cost and economic factors when deciding on residential location choice, but rather focused on security, social, physical, and infrastructural factors.

Table 3: Factors Influencing RLC in Low-Density Neighbourhood of Minna

Factors	Sum	Mean	Decision
Physical factor (Housing)	2270	3.86	Significant
Infrastructure and Amenities	2464	3.51	Significant
Security	2064	4.19	Significant
Social Factor	2287	3.89	Significant
Economic Factor	1311	2.23	Not Significant
Transport Factor	1394	2.37	Not Significant

The study examined the level of relation between the factors influencing residential location choice among households in various density (low, medium, and high) neighbourhoods in Minna. The Pearson product moment correlation was conducted, and the result is presented in Table 4. The result shows that correlation exist between the neighbourhoods' densities, but the relationship is not significant. For example, Table 4 shows that the relationship between factors influencing RLC in high and medium-density neighbourhoods is 0.366 at a significant level of 0.477. This implies a weak level of corelation without significant impact. Similar trend can be observed across the interaction of the neighbourhoods.

This shows that drivers of RLC varies from neighbourhood to neighbourhood based on density or level of income.

Table 4: Pearson's Correlations

Variable		HDN	MDN	LDN
1. HDN	Pearson's r	—		
	p-value	—		
2. MDN	Pearson's r	0.366	—	
	p-value	0.476	—	
3. LDN	Pearson's r	-0.808	-0.010	—
	p-value	0.052	0.985	—

* p < .05, ** p < .01, *** p < .001

Conclusion And Recommendations

This study examined the factors influencing residential choice location in Minna using residential densities of neighbourhoods where households reside as background. The study concludes that factors influencing residential location choice of households varies across space and particularly across neighbourhood densities and income levels. The neighbourhood density and income level of households reflects the factors considered for RLC in urban cities. For example, households in low-income areas of Minna, otherwise called high density neighbourhoods pay little or no attention to the infrastructure or social factors, but more attention to the economic and transport dynamics when it comes to RLC and vice versa for high income neighbourhoods otherwise called low density neighbourhoods.

Neighbourhoods should be provided with adequate basic infrastructure and services through proper designed policies. The provision and restoration of these infrastructures will enhance proper development in the city. Such infrastructure should also be provided at the fringes. Thus, when evenly distributed, it will improve proper development in the

community. Since the availability and condition of infrastructure and the factor responsible for choice of neighbourhood differ with densities, town planners should also take in to consideration the factors for each density when planning for new neighbourhoods.

References

Burgess R and Skeltys N. (1992). Findings from the housing and location choice survey: an overview. Housing and Urban Development Division & Department of Health Housing and Community Services. Australia: Australian Government Publishing Service; 1992.

Fejiten P, Hooimeijer P, and Mulder CH. (2008). Residential experience and residential environment choice over the lifecourse. Urban Studies. 2008;45(1):141–162.

Hazel AM and Moon JK. (2009). Determinants of residential location decisions among the pre-elderly in central Ohio. Journal of Trans Lan. 2009;2(1):47–67.

Giuliani MV. Residential preferences and attachment across the lifespan. In: Spielberg C, editor. Encyclopedia of Applied Psychology. San Diego: Elsevier/Academic Press; 2004:259–266.

Giuliano G, and Small KA. (1993). Is the journey to work explained by urban structure? Urban Studies. 1993;30(9):1485–1500. 30. Kim JH, Pagliara F, Preston J. The intention to move and residential location choice behaviour. *Urban studies*. 2005;42(9):1621–1636.

Givliamo G, and Small KA. (1991). Sub centres in the Los Angeles Region. J Reg Sci U Eco. 1991;21(1):163–182.

Guo JY and Bhat C.R. (2007). Operationalizing the concept of neighborhood: Application to residential location choice analysis'. Journal of Transport Geography. 2007;15(1):31–45.

Hensher DA. (2001). Measurement of the valiation of travel time savings. Journal of Transport Economics and Policy. 2001;35(1):71–98.

Jin J, and Lee H. (2018). Understanding residential location choices: an application of the UrbanSim residential location model on Suwon, Korea, International Journal of Urban Sciences. 2018;22(2):216–235.

Meikle S. (2002). The urban context and poor people. In: Carole Rakodi, Tony Lloyd-Jones, editors. Urban Livelihoods, A people Centered Approach to Reducing Poverty. 2002.

Okesoto JO, Oke GO, and Olayiwola KO. (2014). Residential location preference of Lagos Central Business District working population. American Journal of Social Issues and Humanities. 2014;4(1):45–55.

Petkar AS and Macwan JEM, (2018). Criteria analysis of residential location preferences: An urban dwellers's perpsctive. International Journal of Urban and Civil Engineering. 2018;12(1):49–55.

Poku-Boansi M, and Adarkwa K.K. (2016). Determinants of residential location in the Adenta Municipality, Ghana. *Geo Journal*. 2016;81(5):779–791.

Sanit P, Nakamura F, and Tanaka S, (2013). Location and mode choice decision mechanism analysis of multi-worker household in Bangkok, Thailand. *Journal of the Eastern Asia Society for Transportation Studies*. 2013; 10:1243–1257.

Sinniah, GK, Shah MZ, and Vigar G, (2016) Residential location preferences: *new perspective. Transportation Research Procedia*. 2016; 17:369–383.

Winstanley A, Thorns DC, and Perkins HC. (2002). Moving house, creating home: Exploring residential mobility. Housing Studies. 2002;17(6):813–832.

Wu W. (2006). Migrant Intra-urban Residential Mobility in Urban China. *HousingStudies.* 2006;21(5):745–765.

Spatial Distribution Pattern of Public Water Access in Makurdi, Nigeria

Begha, M.C.[1], Sanni, L.M.[1]; Akande, S.O.[1] & Aremu, R.[2]
[1]Department of Urban and Regional Planning, Federal University of Technology, Minna, Nigeria
[2] Department of Urban and Regional Planning, Kogi State Polytechnic Lokoja, Nigeria
Corresponding Author: olaxxy75@gmail.com

Abstract

Water is explicitly linked with economic progress and developmental trajectories of most countries and regions of the world. However, despite its significant contribution to quality of life, public health and socio-economic development, water scarcity has continuously remained one of the most excruciating problems around the globe. In view of the disproportionate nature of water scarcity, both in space and time, this study examined the spatial distribution pattern of public water access in neighbourhoods of Makurdi, Benue State, Nigeria. By utilizing cluster sampling technique, data on household water sources, water stress features (duration of supply, time and distance) and challenges were obtained through questionnaire administered on 378 households in 13 neighbourhoods in the study area. The data were analyzed using descriptive (frequency and percentage) and inferential statistics (independent T-Test). Findings from the study revealed that households in the study area are characterized by low level of access to public water supply (0.35) and rely on other informal non-network water sources to augment improved water source. The empirical findings also indicated that access to public water supply vary among the neighbourhoods in the study area ($t=30.83$; $df=12$; and $Sig=<.001$). The primary challenge to equitable distribution and access to public water in Makurdi are political factor (3.34) and economic factor (3.18). As a recommendation, the government should invest more in the provision of public water supply infrastructure in Makurdi to help increase daily duration of water access in the study area within reasonable time and distance.

Keywords: Access; Public Water Supply; Neighbourhoods, Spatial Distribution

1.0 INTRODUCTION

Water is a basic requirement of all living beings. It is fundamental for sustaining lives as well as economies. Hence, providing water to all communities and populations is one of the global goals of sustainable development (United Nations 2015). Access to safe water supply is important for human health and well-being (WHO, 2008). But the provision of clean drinking water remains a key incomplete development objective (World Water Assessment Programme (WWAP), 2015). Like all other resources, the distribution of water is not equitable amongst the various sections of the population (Calow and Mason 2014). Inequality in access to water is one of the major reasons behind the water crisis around the world (UNDP, 2006). In 2015, only 58% of the global population had access to piped water on their premises (WHO/UNICEF, 2015).

Access to water, sanitation, and hygiene (WASH) has increased significantly in recent years, as recent official estimates show (Joint Monitoring Programme (JMP), 2017). However, progress has been uneven, and available data highlight inequalities among and within countries. Inequalities exist not only between rural and urban areas, poor and rich, but also between vulnerable groups and the general population. Addressing and eliminating these inequalities have become central concerns in the Sustainable Development Goals (SDGs) era, with a dedicated goal on "reducing inequality within and amongst countries" (SDG 10), as well as across most SDGs, including for example "ensuring availability and sustainable management of water and sanitation for all" (SDG 6).

Regarding access to water, many advances were reported by UN in the MDGs, and 147 out of 215 countries achieved the goal (UNICEF and WHO, 2015). However, the monitoring carried out using the average national coverage conceals inequalities in access to water due to social or economic discrimination. This is shown by several works, which identified the following: a) inequality between rich and poor (UNICEF and WHO, 2019); b) increase in coverage accompanied by an increase in inequality between rural and urban areas (WHO and UNICEF, 2014); c) different coverage rates between national averages and informal settlements or other special communities (Dos Santos *et al.*, 2017; Adams, 2017, 2018) gender and class inequality (Truelove, 2011).

In recent years, much attention has been directed towards assessing the level of water access in many countries and regions of the world with respect to Agenda 2030 of the SDGs (WHO/UNICEF, 2015; United Nations 2017; WHO/UNICEF, 2017). These studies reported consistent progress in access to water across the globe, while neglecting the internal disparities (distribution) in water access. The academic literature also shows relevant efforts to propose and validate instruments and mechanisms for assessing distribution in water access (Wang *et al.*, 2018; Luh *et al.*, 2013; Bain *et al.*, 2014; Pullan *et al.*, 2014; Yu *et al.*, 2014; Flores-Baquero *et al.*, 2017; GinéGarriga and Pérez-Foguet, 2019; Ezbakhe and Pérez-Foguet, 2018), but they have not been implemented at lower scale (household, ward, district, LGA or State) and have only been tested in specific case studies.

Extant review of literature also shows that access to water has been viewed from a unidimensional aspect. That is, access to water has been relegated only to connectivity to water supply mains in most studies (Malakar et al., 2017; Luh *et al.*, 2013; Bain *et al.*, 2014; Pullan *et al.*, 2014;). Going by the SDGs concept of access to water, access to water supply in the real sense of the matter goes beyond household connectivity to public water supply main. For access to water to be established, it must be available (connectivity), within reasonable distance and time and should be affordable. Therefore, for effective policy formulation and planning for improved water distribution and access, water access must be measured using multi-dimensional indicators. However, studies on water access that proceed in a multi-dimensional way are limited in Nigeria and particularly in Makurdi.

Even in the face of global progress in water access, the story remains bleak in Nigeria. More than half of the population is affected by lack of access to safe drinking water and poor sanitation (Galadima, *et al.*, 2011). According to the WorldBank, (2010), water production facilities in Nigeria are "rarely operated to full capacity due to broken down equipment, or lack of power to fuel the pumping". Equipment and pipes are poorly maintained, leading to intermittent supply of pipe borne water in Nigeria. In Makurdi for example, studies by Chia and Ndulue, (2018); Ibaishwa and Abaagu, (2018); Aho *et al.* (2016); and Akali *et al. (*2014) was focused on problems of domestic water supply, gender issues in access to water, sanitation and hygiene, and determinant of residential per capita water demand.

Although the findings of these studies (Chia and Ndulue, 2018; Ibaishwa and Abaagu, 2018; Aho *et al.* 2016; and Akali *et al.* 2014) provides ample information on water access and demand in Makurdi, the result does not reflect the true situation of water access in Makurdi. This is because of the over simplicity of the concept of water access to connectivity to public water supply alone, while neglecting issues on quality, regularity, and affordability. The studies also failed to present a true picture of the distribution pattern of water access due to the aggregation of the result. It is imperative to provide the spatial variation (distribution pattern) in water access in Makurdi town; this will go a long way to improve policy formulation in the right direction. Therefore, this study examined the distribution and access to pipe-borne water in Makurdi town across different neighbourhood densities and socioeconomic class through the multidimensional approach. Hence, the following objectives were evolved from the research questions in other to achieve the aim of the study:

i. Assess the socioeconomic attributes of the households in Makurdi

ii. Determine the level of household water access in Makurdi

iii. Assess the factors impeding access to water in Makurdi

In lieu of this, the study also hypothesized that:

Ho= There is no statistically significant variation in the pattern of public water access in neighbourhoods of Makurdi

Ha= There is statistically significant variation in the pattern of public water access in neighbourhoods of Makurdi

2.0 STUDY AREA AND METHODOLOGY

2.1 Study Area

Makurdi is the capital city of Benue state in northcentral Nigeria. Makurdi lies between Latitude 7° 44N and Longitude 8° 54N. It is located within the flood plain of lower River Benue valley. The physiographic characteristics span between 73-167 m above sea level. Due to the general low relief, sizeable portions of Makurdi are water logged and flooded during heavy rainstorms (Ameto, 2012). This is reflected in the general rise in the level of ground water in wells during wet season. The drainage system is dominated by River Benue which traverses the town into Makurdi North and South banks.

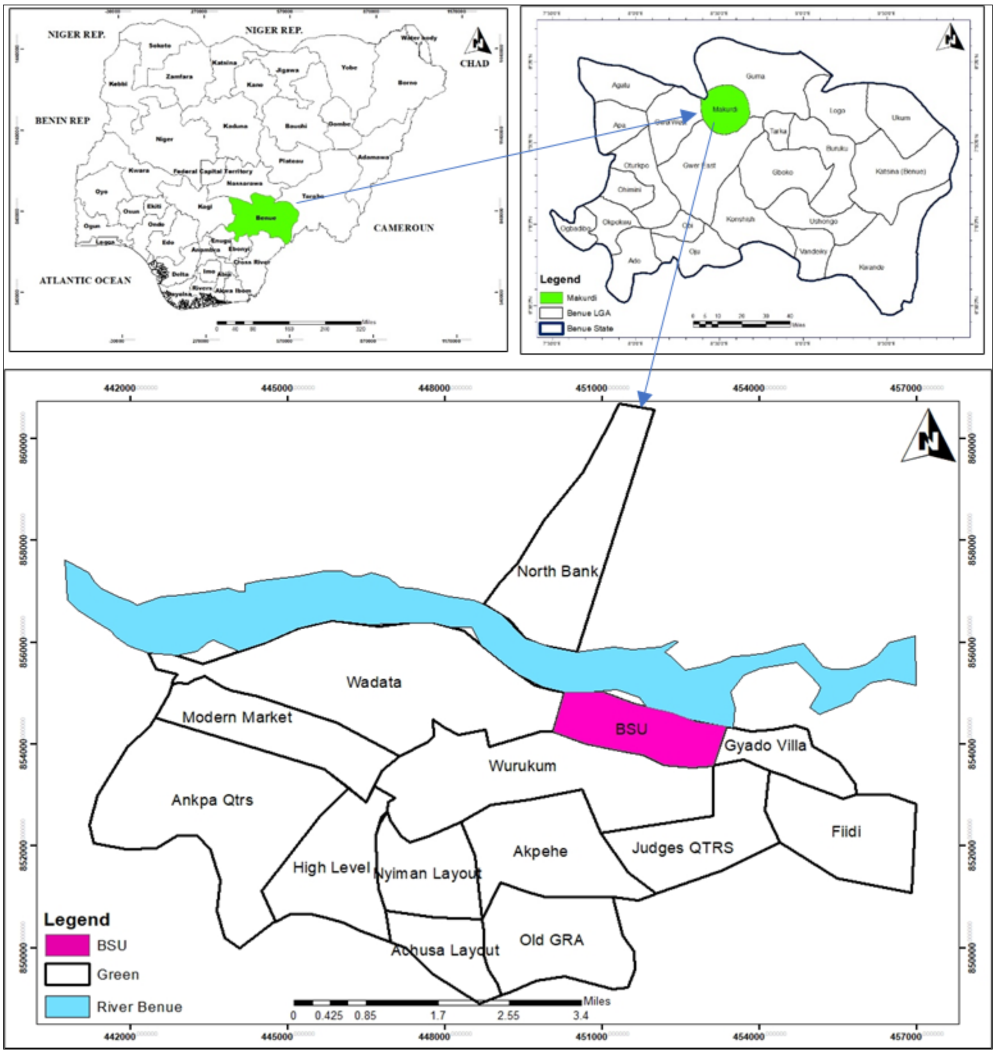


Figure 1: Neighbourhoods Map of Makurdi, Benue State

2.2 Methodology

The study adopts the survey and descriptive research design approach. The data were sourced from primary sources using survey and questionnaire. The data was gathered using a cross sectional approach; that is the data were collected within the same period of time. A total of 378 questionnaires was administered on households across thirteen (13) neighborhoods in Makurdi metropolis. The data collected was subjected to descriptive and inferential analytical techniques and the result were presented in Tables, Charts and maps.

3.0 RESULTS AND DISCUSSION

3.1 Socioeconomic Attributes of Respondents

The study revealed that majority of the respondents were between the age bracket of 36-45 years (31%), respondents between the age bracket of 26-35 years accounted for 30%, while respondents within the age bracket of 46-55 years accounted for 21%. Majority of the respondents were married (64%), while female respondents accounted for 63% and male 37% (Table 1). The population is relative literate as majority of the respondents had attained ND/NCE (31%) and HND/B.Sc. (27%). Table 1 also shows that 34% of the respondents had a household size of 34%, while 27% had a household size of 3-4 and 16% for 7-8 household size.

Table 1: Socioeconomic Attribute of Respondents

Item	Frequency	Percentage
Gender		
Male	240	63%
Female	138	37%
Total	**378**	**100%**
Marital Status		
Single	72	19%
Widow(er)	35	9%
Separated	26	7%
Married	245	65%
Total	**378**	**100%**
Education Attainment		
No formal education	37	10%
Primary	14	3%
Secondary	72	19%
ND/NCE	117	31%
HND/B.Sc.	101	27%
Postgraduate	37	10%
Total	**378**	**100%**
Household Size		
1	24	6%
2	39	10%
3-4	101	26%
5-6	127	34%
Above 6	87	24%
Total	**378**	**100%**
Occupation		
Unemployed	110	29%
Retiree	40	11%
Trader	103	27%
Artisan	11	3%
Civil servant	50	13%
Farmer	27	7%
Others	37	10%
Total	**378**	**100%**

3.2 Household Water Access to Public Water Supply

The level of household access to public water supply was examined using four key indicators; availability of public water infrastructure, duration of water supply, time spent collecting water, and distance travelled to collect water. The cumulative effect of the fur indicators was used to determine level o water access in the neighborhoods. Table 2 shows the distribution of household access to public water supply in the thirteen neighbourhoods in Makurdi. The result shows that availability of public water infrastructures in the neighbourhoods varies from one neighbourhood to the other. For example, 70% of the households in Nyiman layout had access to public water infrastructure, while 60% of the households in neighbourhoods in Old GRA and Wurukum had access to public water infrastructure.

However, in other neighbourhoods, less than 50% of the households had access to public water infrastructure

Table 2: Household Access to Public Water Supply

	YES	
Neighbourhood	**Frequency**	**Percent**
Gyado Villa	4	14%
High Level	6	20%
Ankpa Quarters	5	26%
Achusa	8	27%
Akpehe	13	45%
North Bank	9	30%
Old GRA	18	60%
Wurukum	18	60%
Wadata	14	47%
Morden Market	8	26%
Fiidi	12	40%
Judges Quarters	7	23%
Nyiman Layout	21	70%
Total	**143**	**37%**

Duration of water access is categorized into four, 1-2 hours, 3-4 hours, 5-8 hours, 9-12 hours, and 13-16 hours. Table 3 shows that majority of the households (49%) enjoy 1-2 hours of water access, 26% enjoy 3-4 hours of water access, while 18% enjoy 5-8 hours of daily water access. The implication is that 97% of the household only expect water supply for less than 8 hours per day, while about 50% of the households rely on 1-2 hours of water access from public water source. The study also revealed that 3% of the households enjoy 9-12 hours of water access, while 4% of the households enjoy 13-16 hours of daily water access (Table 3). The foregoing analysis revealed the poor level of public water access in Makurdi, where more than three quarter of the households had less than four hours of access to public water.

Table 3: Duration of Access to Public Water Supply

Neighbourhood	1-2	3-4	5-8	9-12	13-16
Gyado Villa	11	1	0	0	0
High Level	1	1	1	0	0
Ankpa Quarters	0	0	8	0	0
Achusa	1	2	0	0	1
Akpehe	3	3	5	2	2
North Bank	11	2	0	0	0
Old Gra	12	2	0	1	0
Wurukum	2	6	1	1	1
Wadata	10	4	0	0	0
Morden Market	13	1	0	0	0
Fiidi	1	3	1	0	0
Judges Quarters	0	5	7	0	0
Nyiman Layout	3	6	1	0	2
Total	**70 (49%)**	**37 (26%)**	**26 (18%)**	**4 (3%)**	**6 (4%)**

The study also assessed the time spent by household members when collecting water. The time spent for water collection (to and fro) is presented in Table 4. The result shows that 43% of the respondents spend 30 minutes or less collecting water, 22% spend 46-60 minutes collecting water, while 20% of the respondents spend 31-45 minutes collecting water. In addition, 16% of the respondents reported that they send above 60 minutes collecting water. The foregoing analysis reveals that about 53% spend more than 30 minutes to collects water which is the minimum standard according to the WHO (2006).

Table 4: Minimum Time Spent for Water Collection

Neighbourhood	< 30 Minutes	30-45 Minutes	46-60 Minutes	Above 60 Minutes
Gyado Villa	18	4	4	3
High Level	14	9	4	3
Ankpa Quarters	10	6	2	1
Achusa	15	4	7	4
Akpehe	19	2	6	2
North Bank	10	8	6	6
Old GRA	13	5	8	4
Wurukum	12	3	4	11
Wadata	7	4	6	13
Morden Market	8	6	12	5
Fiidi	9	7	13	1
Judges Quarters	14	8	3	5
Nyiman Layout	12	9	7	2
Total	**161 (43%)**	**75 (20%)**	**82 (22%)**	**60 (16%)**

The minimum distance travelled in search of water by the respondents is presented in Table 5. The result shows that 58% of the respondents travel for less than 400 metres in search of water, while on the other hand, 28% of the respondents travel for 401-800 metres in search of water. Table 4.19 also reveals that 11% of the respondents travel for 801-1200 metres daily in search of water, while 3% of the respondents travel for over 1200 metres in search of water on daily basis. This shows that a significant proportion of the households have access to water within reasonable travel limit of 400 metres as prescribed by the WHO (2006). Although, about 42% of the households travel for more than 400 metres daily in search of water. The spatial distribution pattern of the indicators across the neighbourhoods is depicted in Figure 2-5.

Table 5: Minimum Distance Travelled to Water Source

Neighbourhood	< 400M	401-800M	801-1200M	> 1200M
Gyado Villa	21	1	5	2
High Level	18	9	3	0
Ankpa Quarters	16	2	0	1
Achusa	14	8	7	1
Akpehe	19	5	5	0
North Bank	13	13	4	0
Old GRA	24	6	0	0
Wurukum	18	9	2	1
Wadata	10	15	4	1
Morden Market	11	14	5	1
Fiidi	13	10	3	4
Judges Quarters	19	8	3	0
Nyiman Layout	22	7	0	1
Total	**218 (58%)**	**107 (28%)**	**41 (11%)**	**12 (3%)**

3.2.1 Household Water Access Index and Neighbourhood Distribution Pattern

The spatial distribution pattern of access to public water supply in Makurdi is presented in Table 6. The result shows that only four neighbourhoods had a fair level of access to public water supply in Makurdi, while others had low access to public water supply. The neighbourhoods with fair level of access are Akpehe (0.48), Nyiman Layout (0.48), Old GRA (0.47), and Ankpa Qtrs (0.41). Table 6 also shows the performance of the neighbourhoods by indicators. The neighbourhoods performed fairly well in respect to time spent collecting water (0.43) and distance travelled to water source (0.53). However, the low level of access experienced in the neighbourhoods is occasioned by the very low duration of water access (0.03), and availability of public water infrastructure (0.38).

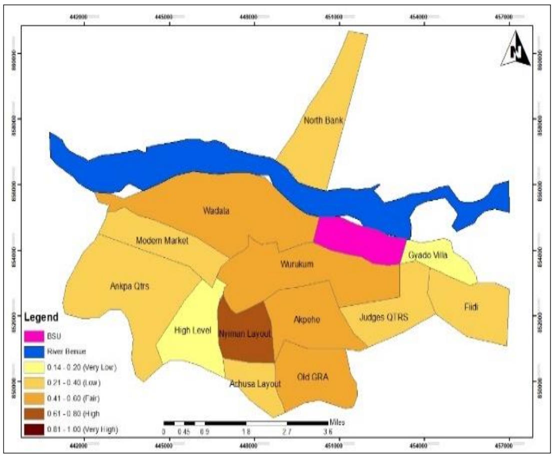


Figure 2: Public Water Infrastructure Availability

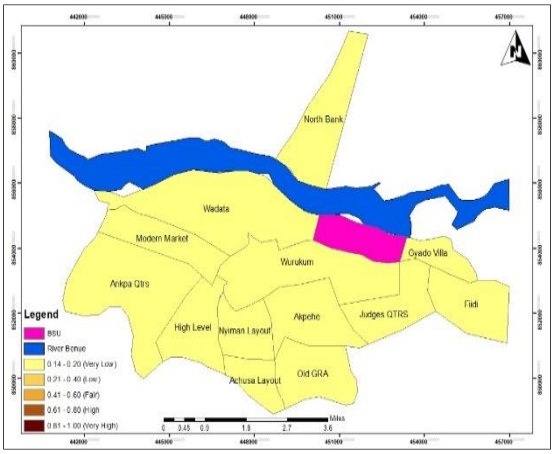


Figure 3: Duration of Daily Public Water Access

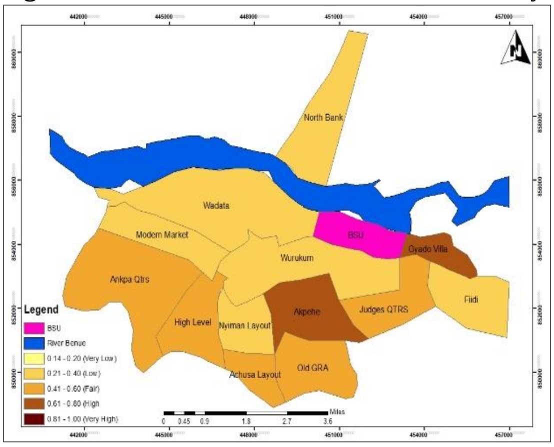


Figure 4: Time Taken to get Public Water

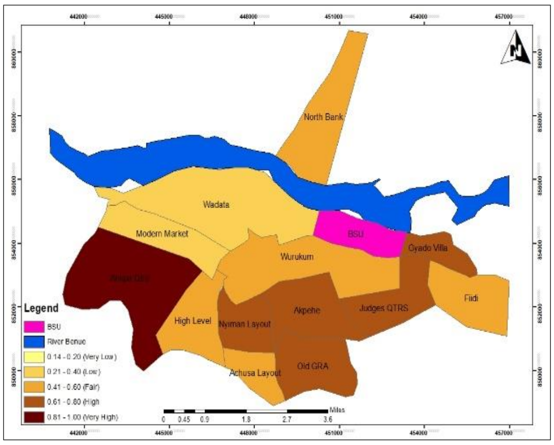


Figure 5: Distance Travelled to get Public Water

Table 6: Household Water Access Index for Neighbourhoods in Makurdi

Neighbourhood	Avail	Duration	Time Spent	Distance Travelled	AGG	Remark
Achusa Layout	0.27	0.03	0.5	0.47	0.32	Low
Akpehe	0.45	0.14	0.66	0.66	0.48	Fair
Ankpa Qtrs	0.26	0	0.53	0.84	0.41	Fair
Fiidi	0.4	0	0.3	0.43	0.28	Low
Gyado Villa	0.14	0	0.62	0.72	0.37	Low
High Level	0.2	0	0.47	0.6	0.32	Low
Judges QTRS	0.23	0	0.47	0.63	0.33	Low
Modern Market	0.26	0	0.26	0.35	0.22	Low
North Bank	0.3	0	0.33	0.43	0.27	Low
Nyiman Layout	0.7	0.07	0.4	0.73	0.48	Fair
Old GRA	0.6	0.03	0.43	0.8	0.47	Fair
Wadata	**0.37**	0	0.23	0.33	0.23	Low
Wurukum	0.47	0.07	0.4	0.6	0.39	Low
Total	**0.38**	**0.03**	**0.43**	**0.58**	**0.35**	**Low**
	Low	**Very Low**	**Fair**	**Fair**		

Note: 0.00-0.20= Very low; 0.21-0.40=Low; 0.41-0.60=Fair; 0.61-0.80= High; 0.81-1.00=Very High

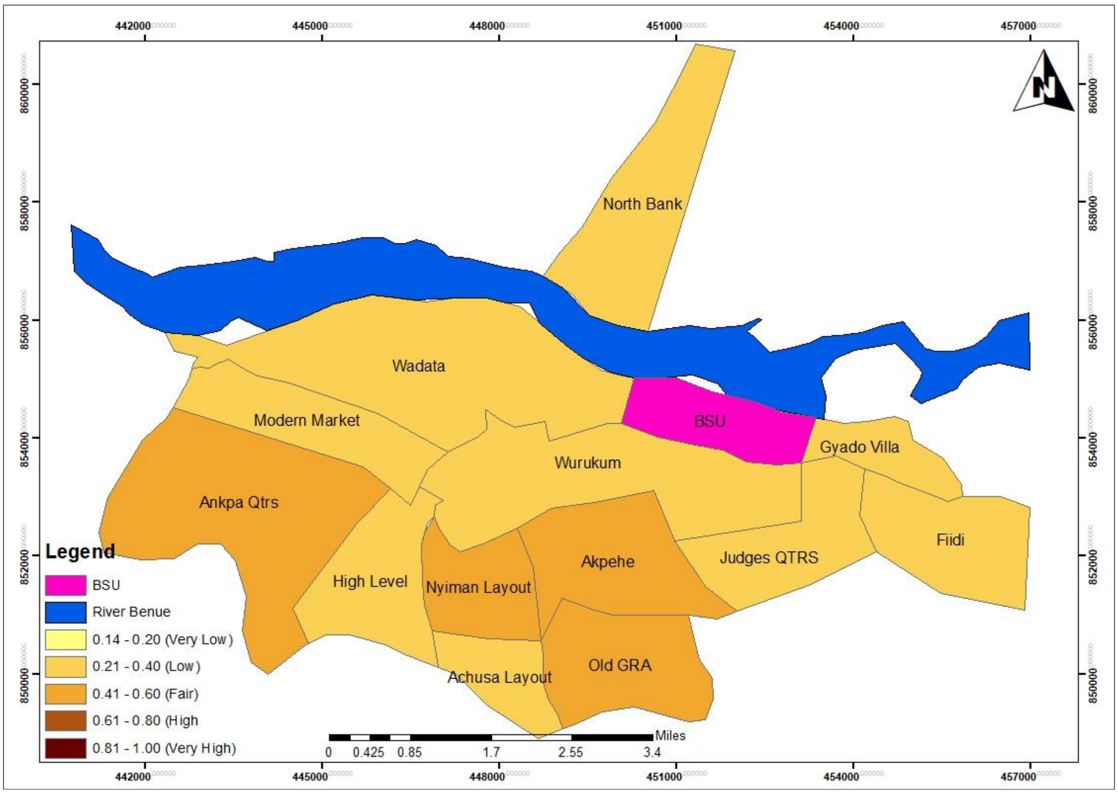


Figure 6: Spatial Distribution Pattern of Public Water Access in Makurdi

Test of hypothesis

One sample T-test was employed as analytical tool to test the study hypothesis. The study hypothesized that there is no significant difference in the level of water access across neighbourhoods in Makurdi. Table 4.27 shows the result of the One Sample T-test. The result recorded a t-value of 30.83, degree of freedom of 12, and a p-value of <.001. Since the p-value is less than 0.05 at 95% confidence level, there is significant difference in the level of water access across the neighbourhoods in Makurdi. Hence, the null hypothesis was rejected while the alternative hypothesis was accepted.

Table 7: One Sample T-test of Water Access in Makurdi

					95% Confidence Interval of the Difference	
	t	df	p-value (2-tailed)	Mean Difference	Lower limit	Upper limit
WAI	30.83	12	<.001	0.57	0.53	0.61

WAI= Water Access Index

3.3 Challenges to Public Water Access in Makurdi

The study also assessed the factors militating against effective access to public water supply in Makurdi. The factors were categorised into four-dimension, physical factors, economic, social, and political factors. The result of the analysis is presented in Table 8. Political factor was identified as the primary factor affecting access to public water in Makurdi with a weighted mean score of 3.34. Economic factor ranked second with a weighted mean score of 3.18, this factor covers cost of water infrastructure installation and cost of water, and income of household among others. Social and Physical factor ranked third and fourth with a mean score of 3.05 and 3.02 respectively.

Table 8: Factors Affecting Access to Public Water Supply in Makurdi

Challenges	**Weighted Sum**	**Weighted Mean**	Rank
Physical	1143	3.02	4th
Economic factor	1203	3.18	2nd
Social Factor	1153	3.05	3rd
Political Factor	1264	3.34	1st

4.0 Conclusion and Recommendations

This research has employed the multidimensional approach to estimate access to public water supply in Makurdi, Benue State, Nigeria. This is with the view to provide empirical evidence on water access situation of the neighbourhoods in Makurdi and to provide guidelines towards addressing the issue of water access. In view of this, the study was able to provide a vivid experience of the neighbourhoods in respect to public water supply as well as identify areas that require urgent attention in order to achieve water access for all.

Going by the findings of the study, spatial difference can be observed in access to public water supply of households across the various neighbourhoods in Makurdi. The study revealed that access to public water is significantly low in all the neighbourhoods, except in Ankpa Qtrs, Akpehe, Old GRA, and Nyiman layout where access to public water supply is fair. The study also reported that there is significant variation in the spatial pattern of water access. A further significant highlight of this study is the attention paid to each dimension of water access ranging from availability, duration, distance, and time spent to access public water supply. Each dimension of water assess was investigated thoroughly in order to understand the dynamics of water access level in the study area.

Empirical investigation on access to public water supply in Makurdi is a requisite tool for that can be used by authorities in charge of public water provision. This will avail them with the requisite information required for the development of a holistic policy, laws and guideline that will ensure the achievement of water access for all. Aside the issue of access reported extensively in this study, the study also highlights the differentials in the level of public water coverage in the study area. Only 37% of the households sampled had access to public water. This limited water coverage in the study is at variance to the Sustainable Development Goal (SDG) 6.1 which requires extending improved public water coverage by 100%. The implication of this is that un-served households residing in these neighbourhoods lack equitable access and quality water supply, thereby shifting the burden of providing safe drinking and domestic water to the households.

References

Adams, E. A. (2018). Intra-urban inequalities in water access among households in Malawi's informal settlements: Toward pro-poor urban water policies in Africa. *Environmental Development*, *26*, 34-42.

Aho, M. I., Akpen, G. D., & Ivuwe, P. (2016). Determinants of residential per capita water demand of makurdi metropolis. *Nigerian Journal of Technology*, *35*(2), 424-431.

Bain, R., Wright, J., Yang, H., Gundry, S., Pedley, S., & Bartram, J. (2014). 16. Improved but not necessarily safe: Water access and the Millennium Development Goals. *Global Water: Issues and Insights*, *89*.

Calow, R., & Mason, N. (2014). The real water crisis: inequality in a fast-changing world. *Overseas Development Institute Framing Paper, London*.

Chia, V. D., & Ndulue, E. L. (2018). The contending issues of domestic water supply in Makurdi metropolis, Benue State, Nigeria. Civil & Environ. Res., 6(9), 89–96.

Dos Santos, S., Adams, E. A., Neville, G., Wada, Y., De Sherbinin, A., Bernhardt, E. M., & Adamo, S. B. (2017). Urban growth and water access in sub-Saharan Africa: Progress, challenges, and emerging research directions. *Science of the Total Environment*, *607*, 497-508.

Ezbakhe, F., & Perez-Foguet, A. (2018). Multi-criteria decision analysis under uncertainty: two approaches to incorporating data uncertainty into water, sanitation and hygiene planning. *Water resources management*, *32*(15), 5169-5182.Flores-Baquero *et al.*, 2017;

Galadima, A., Garba, Z. N., Leke, L., Almustapha, M. N., & Adam, I. K. (2011). Domestic water pollution among local communities in Nigeria-causes and consequences. *European journal of scientific research*, *52*(4), 592-603.

Giné-Garriga, R., & Pérez-Foguet, A. (2019, May). Monitoring and targeting the sanitation poor: A multidimensional approach. In *Natural Resources Forum* (Vol. 43, No. 2, pp. 82-94). Oxford, UK: Blackwell Publishing Ltd.

Ibaishwa, R. L., & Abaagu, A. M. (2018, July). Gender Access to Rural Water Supply, Sanitation and Hygiene in Rural Communities in Benue State, Nigeria. In *PAUWES Research-2-Practice Forum*.

Joint Monitoring Programme (2017). 2017 annual report WHO/UNICEF joint monitoring programme for water supply, sanitation and hygiene. In *2017 annual report WHO/UNICEF joint monitoring programme for water supply, sanitation and hygiene* (pp. 20-20).

Luh, J., Baum, R., & Bartram, J. (2013). Equity in water and sanitation: Developing an index to measure progressive realization of the human right. *International journal of hygiene and environmental health*, *216*(6), 662-671.

Pullan, R. L., Freeman, M. C., Gething, P. W., & Brooker, S. J. (2014). Geographical Inequalities in Use of Improved Drinking Water Supply and Sanitation across Sub-Saharan Africa: Mapping and Spatial Analysis of Cross-sectional Survey Data. *PLoS Medicine*, *11*(4). https://doi.org/10.1371/journal.pmed.1001626

United Nations Development Programme (UNDP). (2006). Human Development Report; UNDP: New York, NY, USA.

United Nations. (2017). Goal 6: Ensure access to water and sanitation for all. Retrieved from http://www.un.org/sustainabledevelopment/water-and-sanitation/

WHO/UNICEF (2019) World Health Organization and United Nations Children's Fund Joint Monitoring Programme for water supply and sanitation (JMP). Progress on sanitation and drinking water update. WHO Press, Geneva.

WHO/UNICEF (2015). Progress on sanitation and drinking water 2015 update and MDG assessment. Geneva: WHO Press. http://www.wssinfo.org/fileadmin/user_upload/resources/JMP-Update-report2015_English.pdf. Accessed 3 Nov 2020.

United Nations. (2015). Goal 6: Ensure access to water and sanitation for all. Retrieved from http://www.un.org/sustainabledevelopment/water-and-sanitation/

Wang, L., Zhang, L., Lv, J., Zhang, Y., & Ye, B. (2018). Public awareness of drinking water safety and contamination accidents: A case study in Hainan Province, China. *Water (Switzerland)*, *10*(4), 1–15. https://doi.org/10.3390/w10040446.

WHO/UNICEF (2017). *Progress on drinking water, sanitation and hygiene*. world health organization and united nations children's fund, Geneva: WHO/UNICEF/JMP

WHO/UNICEF (2014). Targets and Indicators Post-2015: Recommendations from International Consultations. *Comprehensive Recommendations-Updated April 2014*.

World Water Assessment Program (WWAP, 2015), World Water Assessment Programme (WWAP) Mid-Term Report.

Assessment of Environmental Risks in Residential Housing Bosso Niger State.

Olakunle, D.O.[a] & Junaid, A.M.[b]
Department of Urban and Regional Planning, Federal University of Technology Minna, Nigeria.
[a]olakunledorcas@gmail.com; [b]jinaduola@futminna.edu.ng;
correspondence author: olakunledorcas@gmail.com;

Abstract

Environment sector is fraught with risks that have the potential of negatively impacting the lives of the people and the environment now and future, poor housing has a resultant effect on the life of individuals and the status of a nation as a whole. Since housing environment is a very important durable item which intension is to impacts positively on health, wellbeing and productivity of its residents. Assessing risk factors therefore depends to a large extent on how well these risks have been identified and managed. The study examines the risk factors in the residential areas with a view to determine the level of potential impacts on the residents to formulate action plan for its improvement. The study is a geo-spatial and quantitative research and the data collected on spatial distribution of risk factors and its potential impact was analysed using the relative importance index to rank the results. The risk factors examined are epidemic outbreaks, fire outbreaks, flood, rain storm and building collapse, The study shows a significant risk impact with a mean item score (MIS) of 3.19 and Relative importance index (RII) of 0.639. The study recommends among others the need for government to enlighten residents on the importance of environmental sanitation as key tool in minimizing risk of environmental degradation. This will help to mitigate the effects of environmental hazards and in turn create a sustainable environment.

Keywords: Environmental Risk, Poor Housing, Risk Identification, Environmental Sustainability

1.0 Introduction

Housing is an essential necessity of life. Housing plays a vital role in the life of living organisms as it provides the key platform for the life support systems in human settlements (Junaid, 2017). It is considered a social service and a basic right Jinadu (2007). Sanusi (2003), identified housing as a very important durable consumer item, which impacts positively on productivity, as decent housing significantly increases workers‟ health and wellbeing, and consequently, growth and it is one of the indices for measuring the standard of living of people across societies.

As outlined by Adedeji (2004), poor housing has resultant effect on the life of individuals and the status of a nation as a whole. Shelter is central to the existence of men (Kehinde, 2010); He also stated that housing involves access to land, shelter and the necessary amenities to make the shelter functional, convenient, aesthetically pleasing, safe and hygienic. According to him, unsanitary, unhygienic, unsafe and inadequate housing can result into risk thereby affecting the security, physical health and privacy of man. Okafor (2016) asserted that housing all over the world has remained an interdependent phenomenon that faces mankind and it represents one of the most basic human needs which no doubt has a profound impact on the health, welfare and productivity of every individual irrespective of social-economic status, colour or creed.

The increasing rate of urbanization in this area is obvious in the high population concentration, over crowdedness, the development of new and generally unplanned neighbourhoods' and the formation of sprawl settlements (Idowu *et al*. 2020). A recurrent characteristic in Bosso area is the total lack or absence of waste discarding facilities, shortage of development control machineries and poor or the absence drainage systems. All these generate risk factors in the study area, the study is intended to assess the factors that are likely to generate risk in the residential environment.

This study therefore aims at assessing risk factors in the residential areas of Bosso with a view to determining the level of potential impacts.

Literature Review

In the study carried out by Ogundahunsi & Adejuwon (2014), it revealed that housing conditions play a vital role in healthy living and life sustainability. The no findings of the study are the fact that there is a strong relationship between housing condition and the environmental condition of the residents. Other studies (Faelker *et al.,* 2000; Fullilove and Fullilove, 2000; Evans *et al*, 2000; Krieger and Higgins, 2002; Shaw, 2004) have proved that housing condition did affect the environmental condition of residents. From the analysis and the chi-square test carried out, it was concluded that there is a strong relationship between housing condition and environmental condition of dwelling places. Bonnefoy (2007) reported that existing environmental challenges are either directly or indirectly linked to housing conditions in terms of the type and nature of the construction material used, the structural design of the building and the installed equipment. Nigeria one of the fastest urbanizing countries in the world (Raji,2008), with the greatest challenge posed by this urbanization is inadequate housing conditions due to the high rate of rural urban migration resulting to social, economic, environmental and political challenges. A recent study on housing situation in Nigeria put existing stock at 23 per 1000 residents, while the housing deficit is put at between 16million and 17million houses, and N65 trillion will be required to finance the deficit at the average of N3.5 million per unit. This amount is about 10 times the 2016 Nigeria budget proposal.

Housing is not just a physical shelter of four walls and a roof; it is about the quality and condition and this was expanded in the second level of Maslow hierarchy of need. At this level, Maslow's theory demonstrates on how important adequate housing is for the security and positive development (Martin & Joomis, 2007). Housing usually has a significant impact on dweller's safety and wellbeing. An unsafe environment, for instance, increases the likelihood of risk to harm and injury, which could have implications for the whole family's wellbeing. Housing in poor condition is more likely to contain hazards that could create an unsafe environment for the whole family (Ford, *et al.*, 2004).

The provision of adequate, good quality housing for the population has always been a major challenge and task for most nations in the world particularly the developing countries. As such various measures have been undertaken towards this end. However, the major constraint in this respect has always been in defining the criteria for good housing and the impact of poor housing conditions on the psychological wellbeing. In fact, any definition of housing condition needs to encompass on a range of factors that determine the house to be good/bad (Barnes *et al.*, 2013). The obvious one is the physical condition; housing may be deemed to be bad if it is damp, infested, cold, or in a bad state of repair. Housing may also be considered, too bad if it is unable to accommodate the number of people inhabiting it. The environment in which the housing is located is also important. Relevant neighbourhood factors include access to amenities, and environmental pollution is also essential. Security of tenure, the status people attach to housing and the levels of community safety and cohesion in an area are all important features. Housing size, quality, neighbourhood, location and household composition in any analysis of housing seems to be very important measure (Rowley and Ong, 2012). According to Stone (2006) "Housing quality cannot be ignored". The wider concept of "housing" need encompasses many of subjects like housing size, quality, neighbourhood, location, and household composition (Stone, 2006). Indeed, many more can be said on housing condition, but the important argument is on the relationship between housing conditions and wellbeing.

According to Posner (1998) risk is the way in which a condition can cause damage. It is essential to note that risk is an uncertainty of an effect which can result into harmful impact (OGC, 2003). Greenstreet (2012) defined risk in the context of housing production as the probability of non-conformity with building rules and the likely level of damage that may occur to existing and prospect users of the building and the surroundings allied with non- conformity. Thus Adam (1995) emphasized that risk management is a significant aspect in housing design and planning. Therefore, realization of well-designed house in a suitable environment requires the availability of clean air, protective devices and adhering to planning laws (Vanderschueren *et al*., 1996). It is important to assess risk, Rout and

Sikdar, (2017)., define Risk assessment is a systematic process for describing and quantifying the risks associated with hazardous substances, processes, actions, or events.

METHODOLOGY

The study Area

The study was conducted within the geographical area of Bosso. Angwanberi and Al-waziri of Bosso form the basis of analysis for the study. The two neighborhoods have an estimated population of about 22,751 people. Angwan Beri and Al-Waziri lies within the region of Bosso between latitudes 8º 36'2.72''N to 8º39'24.87''N, Longitude 6º24'27.60''E to 6º24'27.60''E within Bosso Local Government Area of Niger State. Bosso local Government Area is one of the Local Government Areas in Minna Niger State, it has its administrative headquarter in Maikunkele town, Bosso town in Bosso Local Government Area is home to one of the campuses of the Federal University of Technology Minna. It is bounded By Katcha, Shiroro, Wushishi and Paikoro Local Government Area. In 2014 Bosso community became home to thousands of refugees fleeing fighting in Borno state.

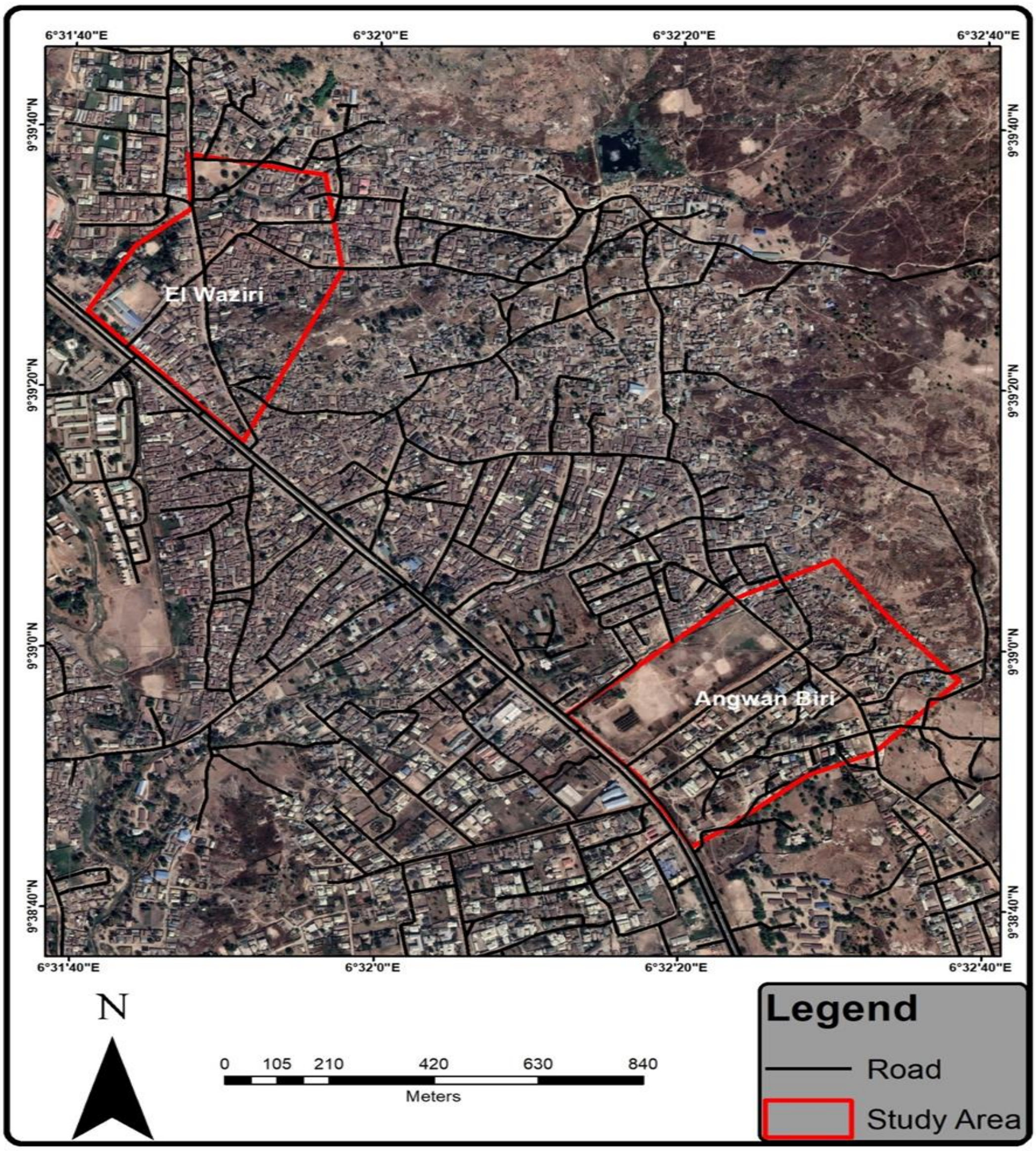


Figure 2: Study Area

Source: Adapted from Niger State Geographic Information System (2020)

Data Collection and Analysis

The data were collected on socioeconomic characteristics, housing characteristics and condition, housing environmental risk factors, The risk factor data that are of significance to this study were fire, flood, rain storm, epidemic outbreaks, building collapse in the study area. The non-probability sampling technique, reason being that the targeted population is not well defined. Purposive sampling was carried out at the study area due to the differences in population. This was done to ensure there was equal probability of capturing the different variables within the study area for effective questionnaire administration.

Result and Discussion

Level and Potential Impact of the Risk Factors in the Study Area

Descriptive statistic for the levels and potential impact of risk factors in Bosso neighbourhoods. Table 2 presents ranking of five (5) risk factors according to their Mean Item Score (MIS) and Relative Importance Indices (RII). From the MIS and RII values assigned to each risk factors it was possible to identify the levels and potential impact of risk factors in Bosso neighbourhoods. The five (5) risk factors had MIS from 4.15 to 2.64 with an average MIS of 3.19 and RII values from 0.830 to 0.528 with an average RII value of 0.639. Base on the results show in Table 2 Epidemics outbreak rank 1st with very significant impact (MIS = 4.15; RII= 0.830), rain storm rank 2nd with significant impact (MIS = 3.79; RII= 0.758), While flood rank 3rd. (MIS = 2.72; RII= 0.545), fire rank 4th (MIS = 2.69; RII= 0.537) and building collapse rank 5th (MIS = 2.64; RII= 0.528) with less significant impact respectively. Also, in general, using the average MIS and RII value (3.19, 0.639), it was identified that Bosso neighbourhoods had a significant risk impact.

Table 1: Cut off point to RII

Cut-off Point	**Remarks/Decision**
RII	Significance
0.81 – 1.00	Very Significant
0.61 – 0.80	Significant
0.41 – 0.60	Less Significant
0.21 – 0.40	Least Significant
0.01 – 0.20	Not Significant

Source: Morenikeji, (2006); Agumba and Haupt, (2014); Shittu *et al*. (2016).

Table 2: The levels and potential impact of risk factors in Bosso Neighbourhoods.

S/No	**Factors**	**Scale**					**MIS**	**RII**	**Ranking**	**Remark/ Decision**
		Very High	High	Moderate	Low	Very Low				
1	Fire	57	63	65	89	103	2.69	0.54	4	Less Significant
2	Flood	33	106	59	82	97	2.73	0.55	3	Less Significant
3	Rain Storm	74	194	69	36	4	3.79	0.76	2	Significant
4	Epidemics Outbreak	174	112	75	7	9	4.15	0.83	1	Very Significant
5	Building Collapse	36	95	47	96	103	2.64	0.53	5	Less Significant
					Average		**3.19**	**0.6**		

N=378

5.1 CONCLUSION

Housing is one of the basic necessities of life; everyone wants to have a place of abode which is very conducive and suitable for human habitation and free from disaster risks. Findings conducted in Bosso areas (Angawan Beri and El-wazirii) and has examined the physical characteristics and condition of the areas. The result shows that the residential area is vulnerable to the following risk factors which are: epidemic outbreak, fire outbreak, flooding, rain storm and building collapse, this is due to the inadequacy of the housing stock and environmental condition in terms of their structural soundness, ventilation, sanitation, toilet, kitchen among others.

From the result accumulated using the Relative Importance Index in ranking the risk factors in the study area, its shows that the major risk factor Base on the results is epidemics outbreak ranking 1^{st} with very significant impact (MIS = 4.15; RII= 0.830), rain storm rank 2^{nd} with significant impact (MIS = 3.79; RII= 0.758), While flood rank 3^{rd}. (MIS = 2.72; RII= 0.545), fire rank 4^{th} (MIS = 2.69; RII= 0.537) and building collapse rank 5^{th} (MIS = 2.64; RII= 0.528) with less significant impact respectively. Generally, using the average MIS and RII value, it was identified that Bosso neighbourhoods had a significant risk impact and this pose a threat on their environment safety, health, live and property. The study therefore recommends that there should be community awareness on various types of environmental risk factors as this is the first step to take to help the resident to keep their environment in check so as to improve their living condition, also the residents should be enlightened and emphasis should be placed on the importance of environmental sanitation as key tool in minimizing the risk of epidemic out breaks.

References

Adams, J. (1995). *Risk*. London: University College, London.

Adedeji, Y. M. D. (2004). Sustainable housing for low-income industrial workers in Ikeja –Ilupeju, Estate.

Barnes, M., Cullinane, C., Scott, S. & Silvester, S. (2013). People living in bad housing: Numbers and health impacts. UK: Shelter.

Ford, J., Quilgars, D., Burrows, R., & Rhodes, D. (2004). Home-owners Risk and Safety Nets: Mortgage Payment Protection Insurance (MPPI) and beyond London: Office of the Deputy Prime Minister.

Idowu, O.O., Bako, A.I., Adeloju, O.T.P. (2020). Analysis of the trend of Peri-Urban Development in Minna Niger State. *Journal of Geographic Information System*, 12(5), 411-431.

Jinadu, A.M. (2007). *Understanding the Basics of Housing, A book of Study for Tertiary Institutions*. Published in Nigeria by Jos University Press (Revised edition).

Kehinde, F. (2010). Housing Policy and Development in Nigeria. In: Omotosa, F., Agagu, A.A., and Abegunde, O. (ed), *Governance, Policies and in Nigeria. Port-Novo, Editions Sonoud Afrique*.

Office of Government Commerce (OGC) (2003). *Achieving excellence in construction: A manager checklist*. London: OGC.

Okafor, B.N. (2016). The Residential Housing Problem in Anambra State (A Case Study of Onitsha Metropolis). *International Journal of Civil Engineering, Construction and Estate Management*, 4(2), 1-18.

Posner, T., & Chicken, J. (1998). *The philosophy of risk*. London: Thomas Telford.

Rowley, S., & Ong, R. (2012). Housing affordability, housing stress and household wellbeing in Australia. Retrieved May 27, 2014, from http://www.ahuri.edu.au/downloads/publications/EvRevReports/AHURI Final_Report_No192_Housing_affordability_housing_stress_and_household_wellbeing_in_Australia.pdf.

Sanusi J. O. (2003). Mortgage financing in Nigeria: issues and challenges*:* Organised by Nigeria Institution of Estate Surveyor and Valuer. In: *Nineth John Wood Ekpenyong Memorial Lecture*. Retrieved February 7, 2009 from www.cenbank.org/OUT/SPEECHES/2003/GOVSP-29JAN.pdf

Stone, M. E. (2006). What is Housing Affordability? The Case for the Residual Income Approach Housing Policy Debate, 17(1), 151-184.http://dx.doi.org/10.1080/10511482.2 006.9521564

Vanderschueren, F., Emiel, W., & Kadmiel, W. (1996). Policy Programme Options for Urban Poverty Alleviation: A Framework for Action at the Municipal Level, Urban Management Programme Policy Paper No. 20, the World Bank Washington DC.

Assessment of Environmental Implication of Final Municipal Solid Waste Dump Site in Ilorin, Kwara State, Nigeria

Yaqub, H. A.[1a] & Morenikeji, O.O.[1b]
[1]*Department of Urban and Regional Planning, Federal University of Technology, Minna*
haleematharbeemborhlarh@gmail.com; oluwole@futminna.edu.ng
Correspondence: haleematharbeemborhlarh@gmail.com

Abstract

Solid waste in most Nigerian cities is a major environmental challenge, Ilorin being the state capital of Kwara State, Nigeria is experiencing population growth yearly, resulting in the increase in human activities which leads to high number of wastes recorded. To enable a conducive environment for the residents to live in, it is extremely important to find the means of reducing the waste. This paper assesses the environmental physical implications of final municipal solid waste dump site in Ilorin, Kwara State. The study adopts quantitative research approach, it starts with identification of the final dump sites in Ilorin and collection of data from the residents of the study area as well as from the agencies responsible for the management of final solid waste dump site in Ilorin. These data were subjected to descriptive statistics. The findings show that Foul odour, Dust at the beginning of rainy season and house flies falls with the average condition, which indicate that most of the just itemized hazard exist on an average scale in the study area a result of those refuse dump being present in that area. The study concludes that waste final dump sites in Ilorin are uncontrolled and do not conform to international standards of operations. This non-compliance results into proliferation of insects and rodents, blowing of litter and causes odour and general environmental degradation. Thereby recommends that There is the need for municipal governments in Nigeria to recognize solid waste management as a major problem and allocate adequate financial and other resources to efficiently and effectively solve the problem.

Keywords: *Solid waste, Final dump sites, Environmental and Physical*

Introduction

Environmental health is the science and practice of preventing human injury and illness and promoting well-being by limiting exposures to hazardous physical, chemical, and biological agents in air, water, soil, food, and other environmental settings that may adversely affect human health. The environment plays a great role in the health of people, a healthy environment equally means healthy people (WHO, 2017). According to the World Health Organization regional office for South-East Asia (2019), Environmental health address all the physical, chemical, and, biological factors exterior to an individual, including all the associated factors influencing behaviours. It comprehends the appraisal and influence of those environmental factors that has the potential to affect health. Its target is to prevent disease and create health-upholding environment.

Solid waste in most Nigerian cities is a major environmental challenge. Chinedu *et al.*, (2018) did an analysis and discovered that the rate of waste generation in Nigeria is estimated at 0.65 – 0.95 kg/capita/day which gives an average of 42 million tonnes of annually generated wastes. This accounts for more than half of 62 million tonnes of waste generated annually in sub-Sahara Africa and an immense problem for the nation arises on where and how to navigate these wastes (Ezeah *et al.*, 2016).

Ilorin being the state capital of Kwara State, Nigeria is experiencing population growth yearly, resulting in the increase in human activities which leads to high number of wastes recorded. To enable a conducive environment for the residents to live in, it is extremely important to find the means of reducing the waste. The Kwara State Waste and Environmental Protection Agency (KWEPA) was established by the Kwara State Government under the ministry of environment, to tackle the encounters faced by the residents of Ilorin metropolis in managing solid waste (Olagunju and Adeniyi, 2018).

The problem of solid waste management is predominant in most third world countries and has increased in recent years due to the rate of industrialization, globalization and population (Butu *et. al.*, 2013). Solid waste management institutions were faced with financial difficulties, understaffing and poor logistics and nature of roads, and social constraints. Ilorin is not an exception to the various effects of the menace of solid waste management, various researches have been conducted by different researches on solid waste in Ilorin such as Oyekan and Sulyman (2015) wrote on the Health Impact Assessment of community-based solid waste management facilities in Ilorin West Local Government Area, Ayanshola *et al.,* (2015) wrote on the evaluation of Municipal Solid Waste management system and willingness to pay for its improvements in Ilorin, Ahmed wrote on waste management in Ilorin Metropolis.

It can be seen that studies done in the past only focused on the environmental impact of solid waste management. No research has been conducted on the Ilorin final municipal solid waste dump site, this thesis aims to bridge the gap of reconciling the environmental and health implications together with the management of the final municipal solid waste by looking at the environmental and health impact of the management of the final municipal solid waste dump site and the various activities carried out by the concerned ministry in ensuring a safe environment. This paper assesses the environmental physical implications of final municipal solid waste dump site in Ilorin, Kwara State.

Study Area

The final municipal solid waste dump site is located at Sokoto Aiyekale, Peke, Eiyekorin express way in Ilorin. Ilorin is the state capital of Kwara State in Northern Nigeria, it is located on latitude 8.496640 and longitude 4.542140 (Figure 1). It covers an area of 765 square kilometre and is situated at an elevation of 320 meters above sea level.

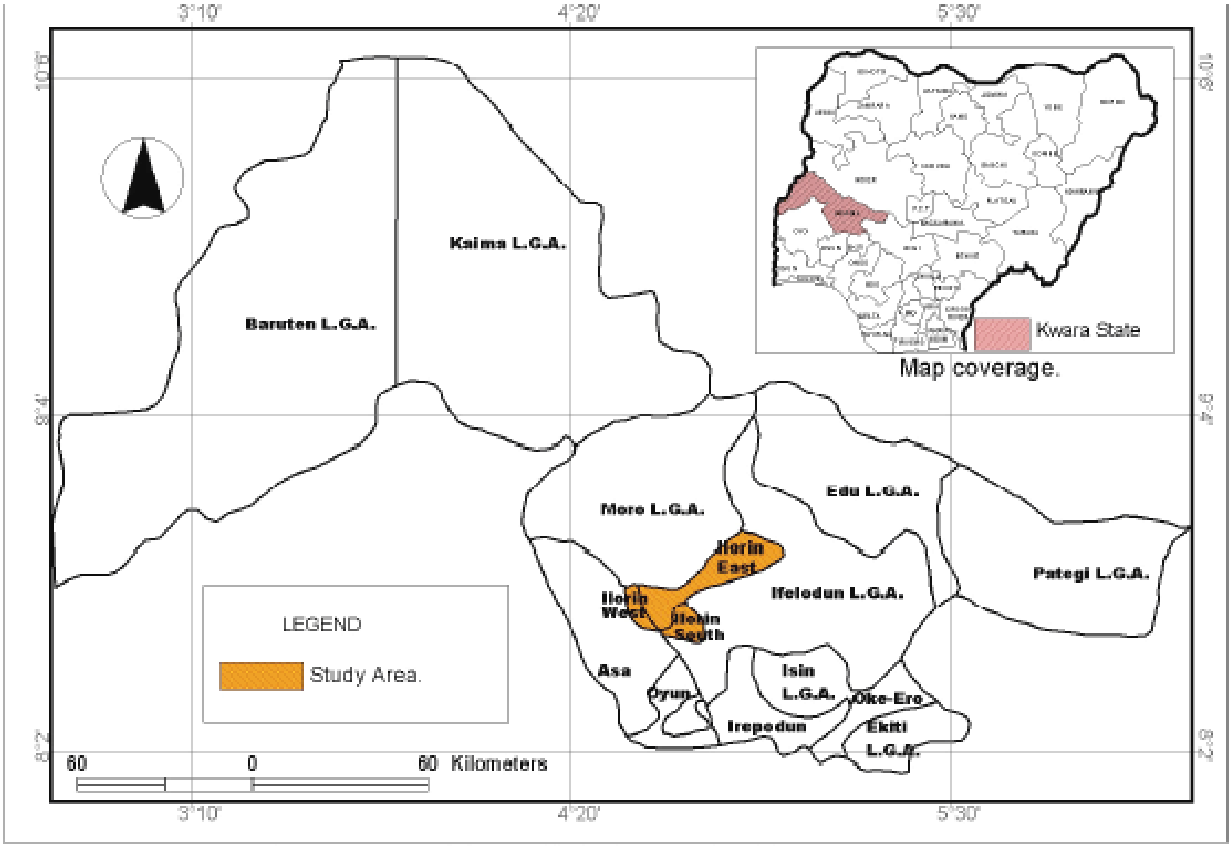


Figure 1: Location of Ilorin in Kwara State, Nigeria.

Source: Ministry of Land and Housing, Ilorin, 2022

Methodology

This research is empirical in nature and requires steps in carrying it out. The first aspect of the research was collection of secondary data for the study which form the springboard for the study. This was followed by design of structure questionnaire that was used to obtain the relevant primary data relating to environmental physical implication of final dump site. The procedure was sequentially thus: identification of the final dump sites in Ilorin (Figure 2). It was followed by collection of soil and water samples around the final dump site data from the residents of the study area as well as from the agencies responsible for the management of final solid waste dump site in Ilorin. These data were subjected to reliability test and ascertain the reliability level of the study.

The data collected was analyses using descriptive statistics, frequency-percentage and tables, supported with charts and graphs where necessary for more clarity. The environmental implication resulting from the final dump sites were rated in to three categories these are: Highly significant, Significant and Not significant which were presented in the table called Definition of significance categories used in the Risk Assessment and Impact Assessment Matrix.

Result and Discussion

Environmental physical implications of final municipal solid waste dump site

This aspect deal with some specific problems suffered from the presence of the solid waste final dump site, they are as follows: foul water, Dust during harmattan, Dust at the beginning of rainy season, Dust at the end of rainy season, Rats and Rodents attack, Houseflies, mosquitoes, Defacing the physical appearance of the environment, injuries from sharp objects of the dumps, pollution of water body and smoke from burning of the waste. Table 1 shows various exposures to solid waste hazard in the study area. The exposure is measured using Linkert Scale. The range of the scale is Strongly Agreed (SA); Agreed (A); Fair (F); Disagreed (D) and Strongly Disagreed (SD).

Table 43: Exposure to solid waste final dump site hazards

S/No	Hazard	Fixed Hazard Grade (1-5)					Ground Total
		SA	A	F	D	SD	
1	Foul water	47	89	62	130	41	**370**
2	Dust during hamattan	5	14	19	183	149	**370**
3	Dust at the beginning of rainy season	29	26	202	60	53	**370**
4	Dust at the end of rainy season	199	24	103	17	24	**370**
5	Rats and other Rodents	7	46	38	55	223	**370**
6	Houseflies	38	50	38	67	187	**370**
7	Mosquitoes	7	19	48	125	171	**370**
8	Defacing the physical appearance of the environment	7	34	46	84	199	**370**
9	Injuries from sharp objects of the dumps	147	72	50	82	19	**370**
10	Pollution of water	17	7	10	130	206	**370**
11	Smoke from burning of the waste	31	10	50	58	221	**370**

Table 2 indicate the response in respect to their exposure on solid waste final dump site hazard. This data is known as Variable Numbers of Respondents (VRR) and the Fixed Hazard Grade (FHG) is ranged from 1-5 of which 5 is the most dangerous.

Fixed Hazards Grade (FHG) – They are those fixed ranges from 1 to 5, were '1' means Very Good; '2' Good; '3' Average; '4' Very Poor and 5 is Extremely Dangerous. Variable Numbers of Respondents (VRR) – refers to the total number of responses for each grade. Sample Size (SSo) - it is referred to as the sample size of the study area, which is 370.

$$\text{Actual Grade (AG)} = \frac{Fixed\ Haxards\ Grade\ (FHG) x\ Variable\ Numbers\ of\ Respondents\ (VNR)}{Sample\ Size} \quad (1)$$

Table 44: Exposure to solid waste final dump site hazards

S/No	HAZARD	1 Poor	2 Fair	3 Average	4 Very Bad	5 Extremely Bad	Actual Grade
1	Foul water	0.13	0.48	0.51	1.40	0.55	**3.07**
2	Dust during hamattan	0.01	0.08	0.16	1.97	2.01	**4.23**
3	Dust at the beginning of rainy season	0.08	0.14	1.64	0.65	0.71	**3.22**
4	Dust at the end of rainy season	0.54	0.13	0.84	0.18	0.36	**2.05**
5	Rats and other rodents	0.02	0.25	0.31	0.60	3.02	**4.19**
6	Houseflies	0.10	0.27	0.31	0.73	2.53	**3.95**
7	Mosquitoes	0.02	0.10	0.39	1.35	2.31	**4.17**
8	Defacing the physical appearance of the environment	0.02	0.18	0.37	0.91	2.69	**4.18**
9	Injuries from sharp objects of the dumps	0.40	0.39	0.41	0.88	0.26	**2.34**
10	Pollution of water	0.05	0.04	0.08	1.40	2.79	**4.36**
11	Smoke from burning of the waste	0.08	0.05	0.41	0.62	2.99	**4.16**

Measurements of physical implication of Living Close to final waste dump site

i. 1- 1.99 = Good Condition (Desirable)
ii. 2- 2.99 = Fair Condition
iii. 3- 3.99 = Average Condition
iv. 4- 4.99 = Very Bad Condition (Undesirable)
v. 5.0 = Extremely Bad (Extremely Undesirable)

Table 2 indicate that Dust at the end of rainy season, injuries from sharp objects of the dumps fall within the is a fair condition, meaning that their effect as a resent of the presence of these refuse dump is minute/ fair on the people around that area.

On the same vein, Table 1 shows that: Foul odour, Dust at the beginning of rainy season and house flies falls with the average condition, which indicate that most of the just itemized hazard exist on an average scale in the study area a result of those refuse dump being present in that area. In addition, table 1 also indicated that: Dust during harmattan, Rats and other rodents' outbreak, mosquitoes, Defacing the physical appearance of the environment, pollution of water and Smoke from burning of waste falls within the very bad condition of the ranging scale, which means that there is a very high existence of health hazard due to the presences refuse dump sites in the study area. It has made the area susceptible solid waste hazard and if urgent measures are not taken, it would be more terrifying in the nearest future.

Measurement of environmental hazard of solid waste final disposal concern

This aspect deals with solid waste hazard and its effect, the factors of consideration are as follows; Fear of Disease, Discomfort from foul odour, irritation from the sight of the dump, fear of people leaving the neighbourhood, fear of persecution by the environmental sanitation body, the neighbourhood being repulsive to needed businesses, friends and relatives not wanting to visit, blooding of road. Table 3 shows measure of concern of risk of exposure to final dump site in Ilorin.

Table 3 indicate the response of the residence in respect to their concern on final solid waste hazard exposure. The variable is then grouped as Variable Numbers of Respondents (VRR) and the Fixed Hazard Grade (FHG) is ranged from 1-5 of which 5 is the most dangerous.

Recall Equation (1) above.

Fixed Hazards Grade (FHG) – They are those fixed ranges from 1 to 5, were '1' means poor, '2' is Fair, '3' is average, '4' is Very Poor and 5 is Extremely Dangerous. Variable Numbers of Respondents (VRR) – refers to the total number of responses for each grade. Sample Size (SSo) - it is referred to as the sample size of the study area, which is 154.

Table 45: Health Hazard

S/N	Measure of Risk	1 Poor	2 Fair	3 Average	4 Very Bad	5 Extremely Bad	Actual Grade
1	Fear of disease	12	38	101	144	75	370
2	Discomfort from foul Odour	22	34	139	82	175	370
3	Irritation from the sight of the dump	26	12	79	197	113	370
4	Fear of people leaving the neighborhood	34	77	108	86	65	370
5	Fear of persecution by the environmental sanitation body	26	82	77	82	103	370
6	The neighborhood being repulsive to needed businesses	31	10	43	127	159	370
7	Friends and relatives not wanting to visit my family	26	14	67	123	139	370
8	Blocking of roads	21	46	53	151	99	370

Ranging Scale unit of Grading (from 1 to 5) is as follows

i. 1.99 = Very Good Condition (Desirable)
ii. 2- 2.99 = Fair Condition
iii. 3- 3.99 = Average Condition
iv. 4- 4.99 = Very Bad Condition (Undesirable Condition)
v. 5.0 = Extremely Bad Condition (Undesirable Condition)

Table 3 shows that Fear of Disease, Discomfort from foul odour, irritation from the sight of the dump, fear of people leaving the neighbourhood, fear of persecution by the environmental sanitation body, friends and relatives not wanting to visit and blocking of road falls within the average condition, it therefore indicate that due to the presence of the refuse dump the area suffers the just listed health hazard in an average manner, that is to so the occurrence are minimal but though exist in that area.

The study established the environmental Health Implication of solid waste final dump site Uncontrolled of final waste dump site is a serious threat man and its immediate environment because it leaves the environment dirty, polluted thus posing treats to the health of the inhabitants from the available records, five major illness were identified as environmental related, these are Malaria, Cholera, Measles, Infections and Typhoid. These illnesses occur when people are exposed to toxins or substances in the environment that make them sick. The more people are exposed to infection the more they are likely to get ill. Environmental features such as waste dump favour the breeding of malaria vectors, as well as parasite reproduction within them, while increased urbanization tends to reduce the rate of Anopheles breeding.

Conclusion and Recommendation

This study has shown that waste final dump sites in Ilorin are uncontrolled and do not conform to international standards of operations. This non-compliance results into proliferation of insects and rodents, blowing of litter and causes odour and general environmental degradation. This is consistent with earlier findings by Arimah & Adinnu (2005). This revelation has practical implications for the siting of solid waste final dump sites in Nigerian urban areas. It is tempting to suggest that in order to minimize negative externalities, final waste dump sites should be located as far away as possible from human settlements. However, this may not suffice, given the scarcity of urban land, especially in Ilorin. Overtime, new settlements may spring up around the dump sites as the case of Ilorin. These negative impacts can be minimized through pragmatic design and proper management of final dump sites within urban areas. Such design and management should enhance the sanitary and aesthetic conditions of the dump sites; it can minimize the generation of greenhouse gases such as methane; and it can also reduce production of leachates that would contaminate underground water sources. All these will go a long way in ensuring that final dump sites in Nigerian urban areas are environmentally acceptable.

In Nigeria, some of the issues that could be addressed as far as waste management practices are concerned include following:

i. There is the need for municipal governments in Nigeria to recognize solid waste management as a major problem and allocate adequate financial and other resources to efficiently and effectively solve the problem.
ii. If the available internal municipal resources are inadequate, such municipal authorities can study the cost and benefits of contracting of waste collection and disposal operations to private operators.
iii. It is important to produce Environmental Impact Statements (EIS) for all new large-scale dump sites in the country. In the EIS, consideration should be given not only to the material aspects of development and environment, but also to those groups in society that are likely to be affected by the development proposals.
iv. Existing and all future dump sites should be designed and operated under appropriate physical planning and engineering standards. Such standards relate to solid waste transportation, accessibility, tipping, quantity and depth of sand (15 cm) to be spread within 24 h of tipping, and provision of fencing around the sites

References

Arimah, A.R, & Adinu, C. (2005). A landfill site selection. Process in GIS modelling. *Proceedings of Sardinia 2003, Ninth International Waste Management and Landfill Symposium. Margherita di Pula, Cagliari, Italy; 6 – 10.*

Ayanshola, B., Ayo.B., & Ibrahim. B. (2010) Selection of landfill sites for solid waste treatment in Damaturu Town-using GIS techniques. Department of Remote Sensing Faculty of Geo-information Science and Engineering, Universiti Teknologi Malaysia, Malaysia. *Journal of Environmental Protection. 2: 1-10.*

Butu, A.W., Ageda, B. R., Bichi, A. A. (2013). Environmental Impacts of roadside Disposal of Municipal Solid Wastes in Karu, Nasarawa State, Nigeria. *International Journal of Environment and Pollution Research*, 1 (1): 1-9.

Chinadu, L, Babayemi, J.O. & Dauda, K. T. (2018). Evaluation of Solid Waste Generation, Categories and Disposal Options in Developing Countries: A Case Study of Nigeria. *Journal of Applied Science. Environmental Management. 13(3): 83 – 88.*

Ezeah, C., Roberts, C. and Phillips, P. (2010): Evaluation of public health impacts of Scavenging in Abuja, Nigeria using Q Methodology. *International Solid Waste Association World Congress (ISWA) 2009, Lisbon, Portugal, 12-15 October 2009.*

Olagunju, I. O. and Adeniyi, E. O. (2012). Health and Economic Implications of Waste Dumpsites in Cities: The case of Lagos, Nigeria. International Journal of Economics and Finance. Vol. 4. No. 4: April 2012.doi: 10.5539/ijef. V4n4 p239 http://dx.doi.org/10.5539/ijef.

Oyekan, A.G and Suleiman, A.J (2015): Urban Poverty in Nigeria*: Towards Sustainable Strategy for it alleviation*. Centre for African Settlement Studies and Development, Ibadan Nigeria. CASSADA Monograph Series 10. pp.1 2.

Residents' Perceptions of Urban Green Spaces and Park Qualities in AMAC Abuja

Ugboh R., Musa H. D.[1] and Ohadugha C. B.[1]
[1]*Department of Urban and Regional Planning, Federal University of Technology Minna, Niger State*
Oge_ugboh@yahoo.com; musaharunad@futminna.edu.ng; chuks@futminna.edu.ng

***Abstract**:*

The characteristics of the parks are one of the main factors determining how the local population views urban green spaces and parks as being usable. This study examines how Abuja Municipal Area Council residents perceive the qualities and characteristics of urban green areas and parks. The study used a quantitative method using a questionnaire and a cross-sectional research design. The study sampled 430 people from the estimated 1,775,432 inhabitants of the AMAC in 2021 using Dilman's (2007) sampling method. According to the standard and service radius of the parks, the survey was conducted using stratified random sampling, with strata within 500m for small parks and 800m for larger parks, and then respondents were chosen at random. The physical characteristics were examined using eight criteria. The results show that, there are 43 urban green spaces in the research region, and based on residents' satisfaction with the parks' quality, 9.5% are extremely satisfied, 72.3% are satisfied, 7.9% are indifferent, and just 10% are dissatisfied. Additionally, it was found that 46.7% of the population is satisfied with the urban green spaces and parks, 35.6% is extremely satisfied, 9.8% is unsure, and 7.7% is not satisfied. The findings suggest that locals do have positive perceptions of the parks and green spaces in the research region, and as a result, the development of further parks and green spaces is promoted in residential communities.

Keywords: Park Characteristics, Residents Perception, Physical Characteristic and Urban Green Spaces

Introduction

Green spaces are a key determinant of how liveable an urban region is, and studies of access to nature have been conducted for over 20 years. They are associated with a wide range of advantages, including health and relaxation. Recent studies have turned their attention to figuring out what motivates city dwellers to engage with and use green spaces. Residents derive varied benefits from urban green spaces, including enhanced air quality, noise reduction, health benefits, improved aesthetics, and buffer zones. Positive opinions of green areas are significant predictors of neighbourhood satisfaction.

The attitude and wellbeing of urban residents are significantly influenced by how easily accessible parks and other green areas are. Goode Vick (2007) stressed the need for the parks and recreation department to have site-specific plans for each of its facilities in addition to a system-wide master plan for parks and recreation. The overall strategic plan for the entire city should include the park and recreation programmes. The sad reality of today is that the majority of urban activities are vying for little space. This study evaluates the effect of urban green spaces and parks on residents' perceptions.

The administration and provision of public parks and recreation has had a significant impact on society, with changes in population patterns, economic expansion, political changes, and new social challenges. A hierarchical framework developed by Driver and Brown in 1978 identified four separate levels of recreational demands: those for activities, those for certain environmental features, those for particular psychological outcomes, experiences, or satisfactions, and those for benefits. Knopp (1972) states that a place's qualities will affect whether or not a certain person will go there to have pleasure. To increase the success of greening developments and treatments, it is important to learn about people' opinions of and preferences for green areas and involve them in the planning process. This study contributes to local literature, the planning process, and policy development by evaluating the effect of urban green spaces and parks on residents' perceptions.

Methods

This study used a cross-sectional design to collect information from many case studies simultaneously. The distribution of urban green spaces and parks in the study area was mapped using GIS spatial mapping and nearest neighbour analysis. A structured questionnaire was used to collect quantitative data on resident opinions of the characteristics and quality of urban green space, as well as user socio-demographic parameters. A total of 430 residents were sampled using stratified random sampling. Questionnaire was administered within 500m radius for small parks and 800m for bigger parks based on the standard and service radius of the parks, then respondents was selected at random

Results

Sociodemographic Characteristics of Residents

Among the total of 430 participants in this study, 206 were males (47.9%) and 224 were females (52.1%). The respondents' ages varied from 25 to 64 years, with the highest activity coming from those in the 25–34 age group (Table 1). A total of 80.7% of respondents have jobs or run businesses that bring in money, while 19.3% are unemployed. Based on the results of the survey, most residents have lived in AMAC for 6–10 years.

Table 46: Sociodemographic Characteristics of Residents (n = 430)

Sociodemographic	Variables	Frequency	Percent
Gender	Male	206	47.9
	Female	224	52.1
Age Group (in years)	25-34	146	34
	35-44	106	24.7
	45-54	141	32.8
	55-64	37	8.6
Level of Education	Secondary education	176	40.9
	Tertiary education	253	58.8
Marital status	Single	188	43.7
	Married	241	56
	Widowed	1	0.2
Occupation	Employed	347	80.7
	Unemployed	83	19.3
	Total	430	100
Length of stay	Less than a year	67	15.6
	1-5 years	202	47
	6-10 years	107	24.9
	11-15 years	51	11.9
	Above 16 years	3	0.7

Urban Green Spaces and Parks in AMAC Types, Size and Distribution

The results of the field analysis reveals that there are 43 urban green spaces within the study area and can be seen in figure 1. There are 2 regional parks, 7 district parks, and 34 neighborhood parks distributed within the study area. The parks have an average land size of 1.42 ha. Cachez Gardens Wuse has the most land area (7.92 ha), while Emerald Park and Recreational Centre Garki has the lowest (0.09 ha). This means that parks in the study area have enough acreage for recreation and outdoor activities.

The distribution of the urban green spaces and parks within the study area was assessed using the nearest neighbour analysis. The result reveals the observed mean distance score of x = 422.91 meters, the expected mean distance score of 611.06 meters, the nearest neighbour ratio of 0.692, the z-score of -3.86, and the p-value of 0.0001. The index (average nearest neighbor ratio) is 0.69, which is <1, indicating that the distribution pattern of urban green spaces and parks in the Abuja area Council appears to be clustered. The z-score (-3.86) suggests that there is a less than 1% likelihood that the clustered pattern could be the result of random chance as presented in Figure 2.

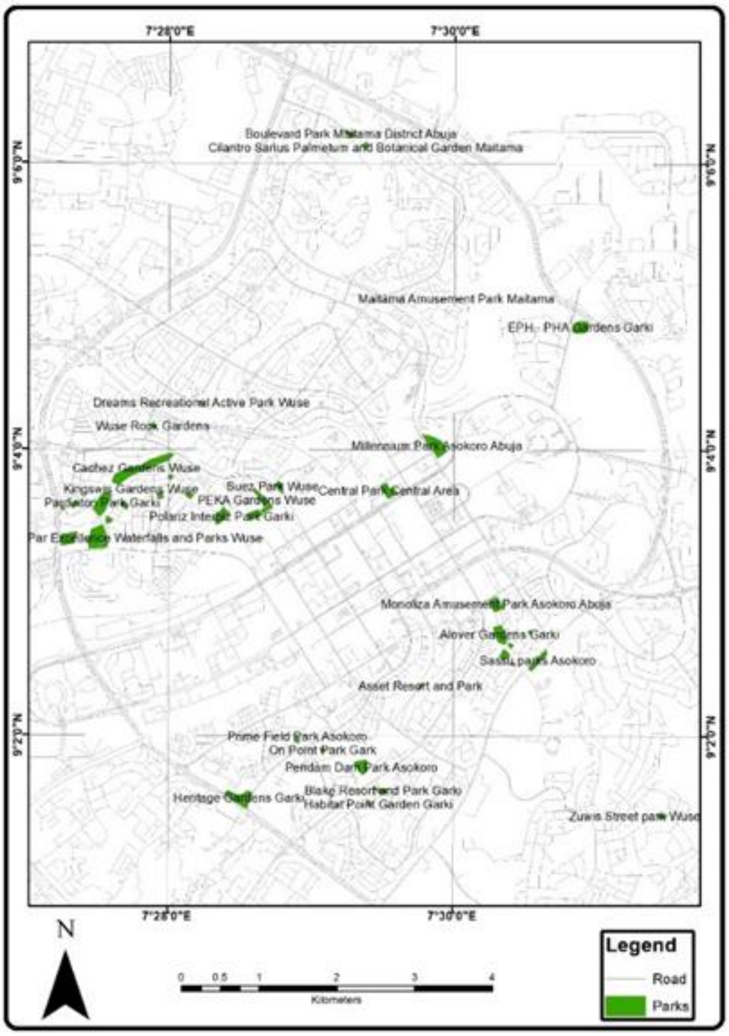


Figure 1: Green spaces and parks in AMAC

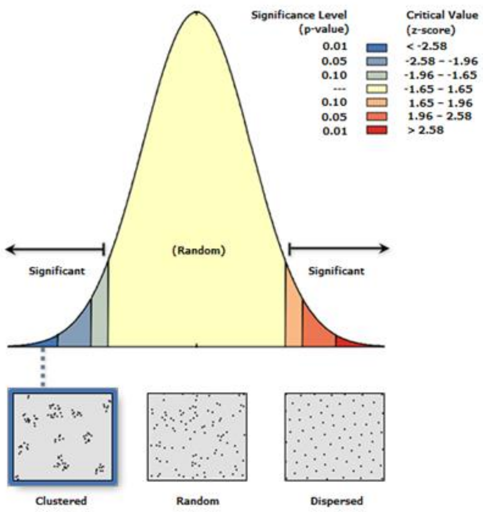


Figure 2: Nearest Neighbour Analysis of Green Spaces and Parks in AMAC

This means that the urban green spaces and parks in the area are close to each other in space, and their distribution is clustered. This finding is supported by other related studies (Bao *et al.*, 2023; Bian, Chen, and Zeng, 2022; Xie and Wu, 2008).

Physical Characteristics of the Green Spaces and Park

The residents' perceptions of eight physical characteristics of urban green spaces and parks in AMAC were assessed using a 5-point Likert scale. The results (see Table 2) showed that 68.6% of residents believe the parks are clean and well-maintained, 63.5%) have good facilities, and 77% have sufficient car parks.

Table 47: Residents' Perception on Physical Characteristics of Urban Green Spaces and Park in AMAC

Characteristics	Degree of Agreement (n = 430)				
	Strongly Agreed	Agreed	Neutral	Disagreed	Strongly Disagreed
Park Cleanliness and maintenance	14.0%	68.6%	17.4%		
Park facilities	7.4%	63.5%	17.4%	9.3%	2.3%
Existence of car parks	7.4%	77%	7.7%	7.9%	
Existence of water bodies	16%	13.5%		49.8%	20.7%
Tranquillity of parks	2.1%	68.4%	11.9%	17.7%	
Existence of playground	7.2%	41.2%	34.7%	16.5%	0.5%
Richness in animal species	2.3%	12.6%	7.7%	30%	47.4%
Opportunities for sport activities	11.9%	35.3%	20.2%	27.7%	4.9%
Sanitation facilities	2.6%	63%	20%	6.5%	7.9%

The survey findings suggest that the urban green spaces and parks in the research region have no attractive water features, but 68.4% of respondents believe that they are serene. Playgrounds are essential for children to engage in outdoor activities, and the abundance of animal species is a major draw for visitors. The chance for athletic activities is also evaluated, with 35.3% of inhabitants agreeing that the parks provide opportunity for sporting activities, 27.7% disagreeing, 20.2% remaining neutral, 11.9% strongly agreeing, and 4.7% strongly disagreed. Additionally, the necessity for cleanliness in parks is crucial, with 63% of respondents agreeing that there are sanitation facilities in parks, 20% were neutral regarding sanitation facilities, 7.9% strongly disagreed, 6.5% disagreed, and 2.6% strongly agreed. This finding corroborates the findings of Madureira, et al.,2018 and Schipperijn et al.,2013.

Spatial Characteristics of Urban Green Spaces and Park

The outcome of residents' perceptions on spatial aspects of urban green spaces and parks in AMAC can be seen in Table 3.

Table 48: Residents' Perception on Spatial Characteristics of Urban Green Spaces and Park in AMAC

Characteristics	Degree of Agreement (n = 430)				
	Strongly Agreed	Agreed	Neutral	Disagreed	Strongly Disagreed
Large size of the park	0.088	0.377	0.402	0.133	
Existence of quiet and privacy	0.026	0.388	0.36	0.223	0.002
Frequency of visitors	0.253	0.47	0.251	0.026	
Richness in plant species	0.414	0.47	0.077		0.04
Sufficient benches / seat-outs	0.087	0.374	0.2	0.34	
Security	0.14	0.68	0.174		
Attractiveness	0.07	0.605	0.279	0.047	
Scenic value	0.079	0.6	0.237	0.084	
Accessibility	0.321	0.505	0.174		
Economic activities	0.435	0.467	0.098		

In a spatial context, the size of the park was evaluated, and it was determined that 40.2% of respondents were neutral (undecided) about the size of the parks, 37.7% of respondents agreed that the sizes of parks are large, 13.3% of respondents disagreed that the sizes of parks are large, and 8.8% of respondents strongly agreed that parks are large. Similarly, the parks' environments were evaluated for their amount of seclusion. 38% of respondents agreed that parks are peaceful and private; 36% were indifferent on the parks' quietness and privacy; 22.3% disagreed that parks are quiet and private; 2.6% strongly agreed; and 0.2% strongly disagreed that parks are quiet and private.

The analysis of the rate of visitors to urban green spaces and parks revealed that 47% agreed that parks have a high frequency of visitors, 25.3% strongly agreed, 25.1% were neutral, and 2.6% were opposed. Residents' perceptions of the richness of plant species (see plate I) in parks were evaluated, with 47% agreeing that urban green spaces are rich in plant species, 41.4% strongly agreeing, 7.7% disagreeing, and 4% strongly disagreeing. It is important to note that certain green spaces and parks have been established solely for the purpose of preserving plant diversity.

Plate I: Cilantro Sarius Palmetum and Botanical Garden Maitama

The availability of benches and seat-outs in the parks were surveyed and it was discovered that 37.4% agrees that most urban green spaces and parks in AMAC do have sufficient seat-outs, 34% disagrees that green spaces do have sufficient seat-outs, 20% were neutral about the sufficiency of seat-outs while 8.6% strongly agrees that there are sufficient seat-outs for users in urban green spaces (Plate II).

Plate II: Benches at NAF Arcade Water Park Wuse

The majority of AMAC's parks have a high level of security, with 68.6% of locals believing that parks are secure, 17.4% are unsure, and 14% strongly agree. Additionally, over 60.5% of people think that urban green spaces and parks are appealing, with 27.9% being ambivalent about the park's beauty, 7% of respondents strongly agree that parks are beautiful, and 4.7% disagree with the park's attractiveness. Additionally, over 82.6% of respondents agree that urban green spaces within the study area are accessible, and economic activities are also present in most of the urban green spaces and parks in AMAC.

Urban Green Spaces and Park Quality

The level of resident satisfaction with the quality of urban spaces and parks in the study area was found to be 72.3%, 9.5% highly satisfied, 10% dissatisfied, 7.9% indifferent, and 0.2% extremely dissatisfied (See Table 4). Additionally, the preference for investing in the quality of public green spaces was found to be 59.8%, while 25.1% indifferent, 10.2% dissatisfied, and 4.9% extremely satisfied. This indicates that residents were satisfied with the investment on the quality of public green areas in AMAC. Similarly, 58.6% of respondents were satisfied with the functions of the urban green space and park, whereas 20.2% were neutral, 18.4% were extremely satisfied, and 2.8% were dissatisfied. Also, the degree of satisfaction among residents based on the frequency of visitations to public parks reveals that 55.8% are satisfied, 24.7% are highly satisfied, 17.4% are neutral, and 2.1% are dissatisfied. This is evidence that residents are satisfied with the function of the urban green space and parks in their neighbourhood, as well as their visitations.

Regarding resident satisfaction, park aesthetic preferences were evaluated, and it was determined that 71.9% of residents are satisfied, 15.6% are dissatisfied, 8.1% are neutral, and 4.4% are highly satisfied. To discover how residents perceived the park's suitability, its compatibility was also evaluated. The results show that, 59.3% are satisfied with park compatibility, 23.0% are extremely satisfied, 15.3% are neutral, and 2.3% are dissatisfied.

Table 4 Residents Degree of Perceived Residents Satisfaction of Parks Characteristics

Characteristics	Residents Degree of Satisfaction				
	Very Satisfied	Satisfied	Neutral	Dissatisfied	Very Dissatisfied
Quality	9.5%	72.3%	7.9%	10.0%	0.2%
preference in investing	4.9%	59.8%	25.1%	10.2%	
Park's function	18.4%	58.6%	20.2%	2.8%	
Park visitation	24.7%	55.8%	17.4%	2.1%	
Aesthetic	4.4%	71.9%	8.1%	15.6%	
Compatibility	23%	59.7%	15.3%	2.3%	

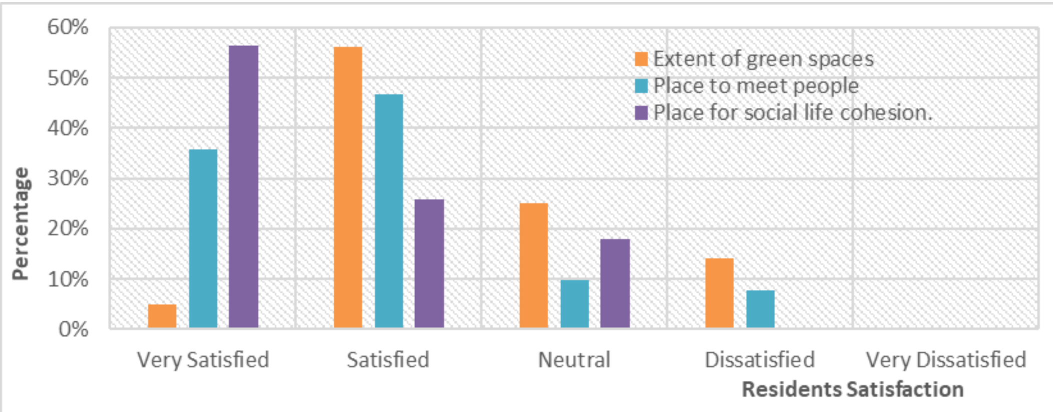


Figure 3: Residents satisfaction on parks as a place for social life cohesion.

The number of green spaces available influences the number of facilities and activities that can be accommodated. Survey result in Figure 3 shows that 56% of residents are satisfied with the number of green space available, 25% are neutral, 14% are dissatisfied, and 4.9% are extremely satisfied. Urban green spaces and parks offer a friendly atmosphere and are in good spots, they are places where people gather. According to the research result, 46.7% of AMAC residents are satisfied with the urban green spaces and parks, 35.6% are very satisfied, 9.8% are not sure, and 7.7% are not happy. Parks have been regarded as a location for social cohesion in 82.1% of cases.

When the amenities provided for physical activity in parks were assessed by the residents, the results presented in Figure 4 revealed that 46.3% were satisfied, 37.9% were unsatisfied, 12.6% were indifferent, 2.8% were highly satisfied, and 0.5% were very dissatisfied. The utilization and safety of public parks and urban green spaces are directly impacted by park security. In the study, 61.2% of participants said they were satisfied with the level of protection at the parks, and 11.6% said they were extremely satisfied. Regarding park security, 19.3% of respondents were undecided, while 7.9% expressed dissatisfaction. This implies that park visitors will experience a sense of security while they are there.

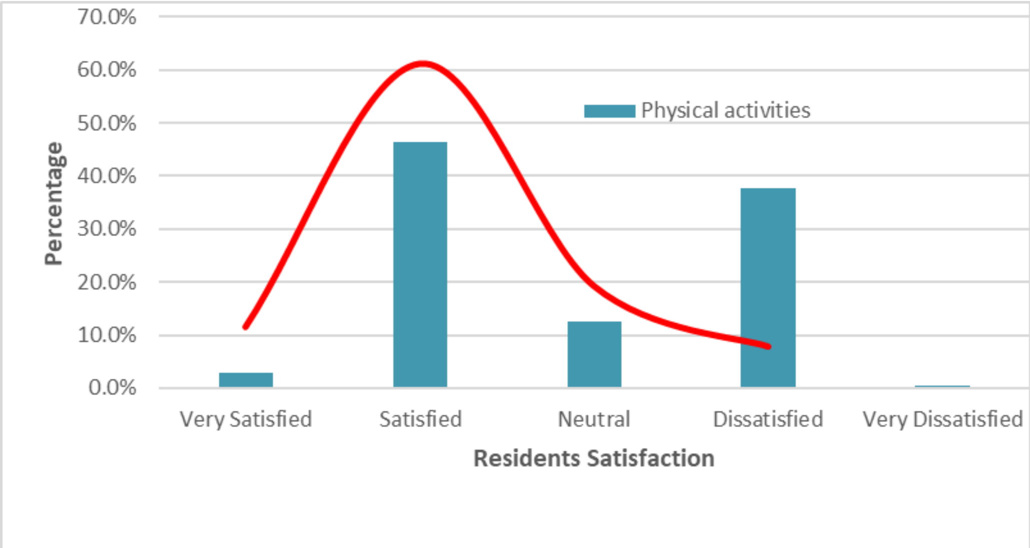


Table 4: Level of Physical Activities and Security at the Parks

A Pearson's correlation analysis was conducted on the resident's perception of green spaces and park characteristics and quality in AMAC and the result is seen in Table 5. The result revealed a statistically significant relationship between residents' perceptions of green space and park characteristics and residents' perceptions of quality (rs = 0.8; *p*-value = 0.001), indicating a strong positive relationship between characteristics and quality of urban green spaces and parks as perceived by residents.

Table 5: link between characteristics and quality of urban green spaces and parks

		Residents' perception of green spaces and park characteristics	Residents' perception of green spaces and park quality
Residents' perception of green spaces and park characteristics	Pearson's r	—	
	p-value	—	
Residents' perception of green spaces and park quality	Pearson's r	0.8	—
	p-value	< .001	—

Conclusions

The findings of this study demonstrate that residents are contented with the state of the urban green spaces and parks in the study region, as evidenced by their favourable perceptions of and use of the parks. This further emphasises the value of including parks in residential neighbourhoods. The development of new parks in residential communities is strongly urged based on the study's findings.

References

Brace, O., Marco, G., & José C. (2021). Gender Differences in the Perceptions of Greenspaces Characteristics. Social Science Quarterly. 102(6): 2640-2648

Chen, D., Long, X., Li, Z., Liao C, Xie, C. & Che, S. (2021). Exploring the Determinants of Urban Green Space Utilization Based on Microblog Check-in Data in Shangai, China. MDPI Forests. 12(1783): 1-15

Conedera, M., Del Biaggio, A., Seeland K., Moretti, M. & Home, R. (2015). Residents' Preferences and Use of Urban and Peri-Urban Greenspaces in Swiss Mountainous Region of the Southern Alps. Urban Forestry & Urban Greening. 14(1): 139 – 147

Knopp, J. A., & Longmuir, I. S. (1972). Intracellular measurement of oxygen by quenching of fluorescence of pyrenebutyric acid. *Biochimica et Biophysica Acta (BBA)-General Subjects*, *279*(2), 393-397.

Lee, A. C., & Maheswaran, R. (2011). The health benefits of urban greenspaces: a review of the evidence. *Journal of Public Health*, 33(2), 212-222.

Madureira, H., Nunes, F., Oliveira, J. V. & Madureira, T. (2018). Preferences for Urban Space Characteristics: A Comparative Study in Three Portuguese Cities. *MDPI Environments.* 5(23): 1-13

Rakhshanderoo, M., Mohdyusof, M. J., Tahirholder, O. M. & Yunos, M. Y.M (2015). The Social Benefits of Urban Open Greenspaces: A Literature Review. *Management Research & Practice.* 7(4): 60-71

Sati, Y. C., Uji, Z. A. & Popoola, O. J., (2016). Perceptible Attributes of Urban Greenspaces in the Architectural Characterization of Metropolitan Areas in Jos, Nigeria. *Research on Humanities and social sciences.* 6(4): 71- 77

Vick, C. G. (2007). Public Parks and Recreation. *Managing Local Government Services: A Practical Guide*, 235.

Wang, H., Dai, X., Wu, J., Wu, X & Nie, X., (2019). Influence of Urban Green Open Space on Residents' Physical Activity in China. *BMC Public Health*. 19(1093): 1-12

Environmental Impact of Automobile Workshop Activities on Soil Quality in Minna, Nigeria

Nagidi; B.M. [a]**; Morenikeji, O.O.** [b] **& Abbas, Y.A.** [c]
Department of Urban and Regional Planning, Federal University of Technology, Minna
[a]bmnagidi@gmail.com; [b]Oluwole@futminna.edu.ng; [c]Abdullahiabbas64@gmail.com
Corresponding authors: bmnagidi@gmail.com

Abstract

Soil is the most vital non-renewable natural resource, an actively living system which performs major environmental functions that consist of diversity of micro and macro fauna and flora, that play major role in maintaining the soil quality. The disposal method of automobile artisans on land can lead to loss in soil quality by minimizing the abundance and variety of microorganisms in soil. The aim of the study is to assess the environmental impact of automobile workshop activities on soil quality in Minna. The study objectives are; determine the spatial distribution of automobile workshops and assess the level of soil contamination in the study area. Twelves (12) soil samples depth intervals of 0-15, 15-30 cm six selected automobile sites were collected by stratified random sampling and extracted sequentially to determine soil contamination of Mg, Cu and Zn. The study revealed that the soil pH level within the study area were slightly acidic to alkaline which ranged from 6.16-8.0. The study revealed that the concentration of magnesium (Mg) recorded ranged from 0.80-13.0 mg/kg. Copper (Cu) concentration recorded ranged from 1.39-4.59 mg/kg, except at Northern bye-pass workshop and Sarkin-Pawa garage ranged 10.5 and 6.21 which is above the stipulated limit of 5mg/kg set by WHO/NESREA. The study also revealed that zinc (Zn) concentration examined ranged from 2.44-7.79 mg/kg. While Northern bye-pass recorded Zinc concentration of 30.6 mg/kg which is above the standard set by WHO/NESREA of 10 mg/kg. The study recommend that special chambers should be created within the workshops to reduce the contamination of heavy metals on the soil.

Keywords: *Soil Contamination, Heavy Metals, Automobile Workshop*

Introduction

The anthropogenic environment remains a constant threat to the quality of soil resources. These resources' qualities are actually the function of such parameters as chemical concentration, biological and physical parameters (Parikh and James, 2012). Soil quality is greatly affected by the spilling or leakage of contaminants (Parikh and James, 2012). These contaminants are usually both human and naturally induced. Automobile workshop or as it is called in Nigerian Parlance, Mechanic workshop waste forms one of the major contaminants of soil quality (Pam, Shaâ, & Offem, 2013). These wastes are usually disposed on the ground within the mechanic workshop which is, invariably, washed by rain water into the ground as contaminants degrading surface soil particles especially, soil pore space and groundwater quality (Utang *et al*., 2013). Automobile workshops and their activities are common sites in Minna, Niger state. The activities that are carried out during vehicle repairs include "working with petroleum products, battery, electrolyte, paints, welding and soldering, panel beating and vehicle body works" with the following wastes; paints, hydraulic fluids, lubricants, solvents, oil spills, carbide and batteries (Adelekan & Abegunde, 2011; Utang *et al*., 2013 in Nebo *et al*., 2018). The likely genotoxicity and mutagenicity of these wastes and the soil itself, which is induced by the genotoxicity of the chemical waste, leaves the soil unfit to withstand natural ecological balancing (Jolaoso *et al*., 2019). This research however, investigate the likely environmental impact of auto-mobile mechanic workshops services on soil viability in Minna, with a view of espousing the genotoxicity potentials of the wastes on the soil quality.

The Study Area

Minna has a land area of about 885 hectares and sited midway between latitude 9° and 10° North of the Equator, and between 6° and 7° East of the Greenwich Meridian.

Minna played an important role as a railway junction connecting Baro Lighter railway with the Kano to Lagos lines and housed a vital railway workshop, including other facilities.

A Federal Road (F126) cut through the heart of Minna, travelling from Zungeru to Abuja with an approximate distance of about two hundred and thirty-seven (237) kilometres. Two major roads separate Minna town into East and West, both roads taking their points from the city gate roundabout and travelling along Maitumbi-Maikunkele and Tundun Fulani axis respectively (Practical GIS International Limited, 2021; Minna Master plan, 1980; and Jiya, 1977) (See Figure 1).

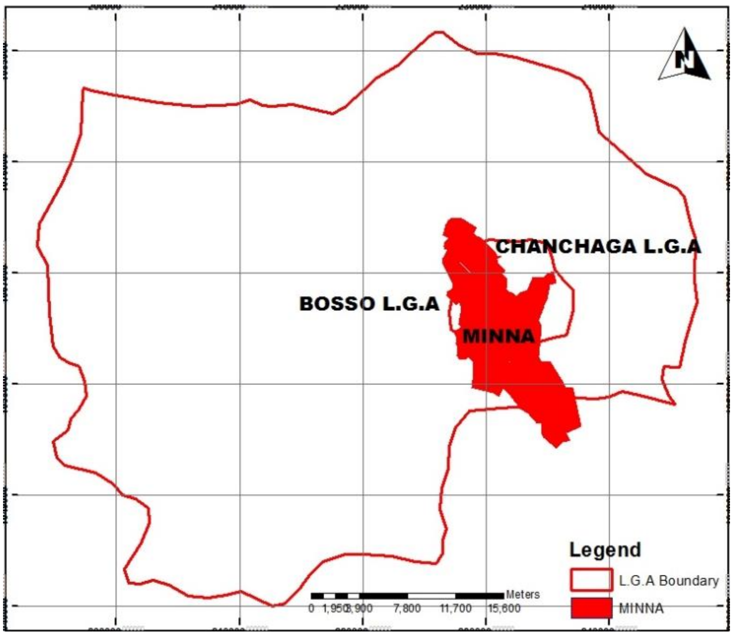


Figure 1: Location of Minna within LGAs.
Source: Niger State Ministry of Lands and Housing, 2015

Literature Review

Concept of Soil

Soil plays a significant role in the preservation of living organisms and covers most part of the earth surface, excluding surface water areas. It played host to abiotic and biotic elements, being the pivot for ecosystem functionality (Stephen *et al.*, 2017). Soil is natural elements that are porous in nature and are constituent of both organic and inorganic matters, catalysed by the relationship between the "earth's crust, atmospheric and biological" factors brought about by a sluggish geological process (Balasubramanian, 2019). The soil quality is the viability of a soil to be able to support and sustain plant and animal productivity, water and air quality and human health and habitation (Doran & Parkin, 1994; Toluwanimi, 2014). The quality of every soil determines its environmental conditions as it forms the bedrock for ecological environmental wellbeing.

Soil Pollution and Heavy Metals

The concentration of pollutant (heavy Metals) in soil and their impact on ecosystems can be influenced by many factors such as the parent rock, climate and anthropogenic activities (Jia *et al.*, 2010). Among the pollutants that persist and accumulate in the soils include; inorganic toxic compounds, organic wastes and organic pesticides (Misra and Mani, 2009; Jia *et al.*, 2010). Heavy metal contaminated soils have been estimated to represent about the 35% of polluted soils (EC, 2014). The accumulation of heavy metals in soils poses a risk to the environmental and human health. Heavy metals accumulate in the body tissues of living organisms (bioaccumulation) and their concentrations increase as they pass from lower trophic levels to higher trophic levels (a phenomenon known as bio-magnification) (Ali *et al.*, 2013).

Contamination of Soil in Auto-Mechanic Workshops

The common chemicals used by automobile workshops are; lubricating oils (include waste oil), fuels, chemical solvents and other cleaning fluids, brake fluid and hydraulic fluids, grease, and coolants (Adewoyin, 2013 & Best Practice Guidelines for Storm Water Pollution and Prevention, Automotive Workshop, 2010). According to Fayiga *et al.* (2018), who studied of heavy metal contamination in auto workshops in Accra, Ghana. The study found out that certain heavy metals (Zn, Pb, Cu, and Ni especially) are directly connected to anthropogenic activities. The study also revealed that Pb was found to be more lethal with high concentration around electrical repairs areas.

Also, Utang *et al.* (2013), in their study impact of automobile workshops on heavy metals concentration in urban soil in Obio/Akpor, Rivers State, Nigeria. The authors findings revealed that their presence of heavy metals in soils within the auto-workshop with mean value of Hg (3.07), Pb (91.0), Cd (5.63) respectively. A similar study carried out by Ilemobayo and Kolade (2008), on profile of heavy metals from automobile workshops in Akure, Nigeria. The study revealed that Ba, Cu, Zn and Fe were of high concentration of 151.4, 782.2 and 634.3 mg/kg super (-1) at Ilesha-Garage. While, Pb and Cr have concentration of 292.4 and 181.8 mg/kg at Ijapo and Ni and Co have 62.1 and 109.4 mg/kg super (-1) respectively at Oyemekun.

Pam *et al.* (2013), assess concentration levels of heavy metals in soil around major auto mechanic workshop clusters in Benue State. The study reveals that Cu ranges from 254-1,348; Pb, 283 - 665; Zn, 295-553; Mn, 58.8-272.; Ni, 18.0 - 41; and Cd, 10.50-12.7. Demie, (2015), investigated the extent of soil contamination by heavy metals in auto mechanic workshops in the city of Shashemane, Ethiopia, using the USEPA and EU standards. The result of study showed that the overall mean concentrations of the heavy metals viz. chromium (Cr), lead (Pb), nickel (Ni), cadmium (Cd) and cobalt (CO) were 290.1, 782.1, 443.6, 133.1 and 331.0 ppm respectively which is extremely higher than USEPA and EU regulation standards.

Similarly, Abidemi (2011), who assessed soil heavy metal pollution by various allied artisans in automobile workshop in Osun State, Nigeria. The study revealed that there is high concentration of Co, Cd, and Pb in certain section of the auto-mechanic workshop. Ibrahim *et al. (*2019), reported that indecorous handling of wastes from auto-mechanic workshops has been one of the principal sources of that has led to a rise in the level of heavy metals in the environment in most Nigerian cities.

Material and Methods

Methodology adopted for this study is the multi-stage approach such as geo-spatial and quantitative methods. The geospatial techniques involve process of satellite imageries of the study area using ER Mapper 6.1 and ArcGIS 10.0, software to determine the spatial distribution of automobile workshops in Minna. While, quantitative approach in this study includes field measurement, laboratory test and questionnaire administration and interviews with the auto-mechanic operators. Two (2) soil samples for the study were collected from each of the six selected auto-mechanic workshop in Minna. The soil sample was taken at 0-15cm and 15-30cm at 30m and 60 meters respectively. The samples were sundried and sieved for analysis and kept in a labelled polythene bag. A 2g of each sample was accurately weighed into a washed and dried kjeldhal flask. 10ml of nitric/ perchloric acid was added to each sample as preservatives for about 10 minutes at 100-150^oC, the temperature of the digester was then increased to 230^oC. The physio-chemical parameters are (Cu, Mg, and Zn) determine the soil contamination in the study area.

Result and Discussion

Spatial Distribution of Mechanic Workshop in Minna

There are 110 mechanic workshops within the study area, an average nearest neighbourhood analysis was carried out on the 110 mechanic workshops to determine the distribution pattern of the workshops and the results obtained are: Observed Mean Distance: 204.629 Metres, Expected Mean Distance: 492.695 Meters, Nearest Neighbour Ratio: 0.415, z-Score: -11.73, p-value: 0.000000. The result indicates that the distribution of the mechanic workshops in the study area is clustered and given that the z-score is -11.73 it shows that there is a less than 1% likelihood that this clustered pattern could be the result of a random chance. Figure 4.1 shows the spatial distribution of mechanic workshops in the study area.

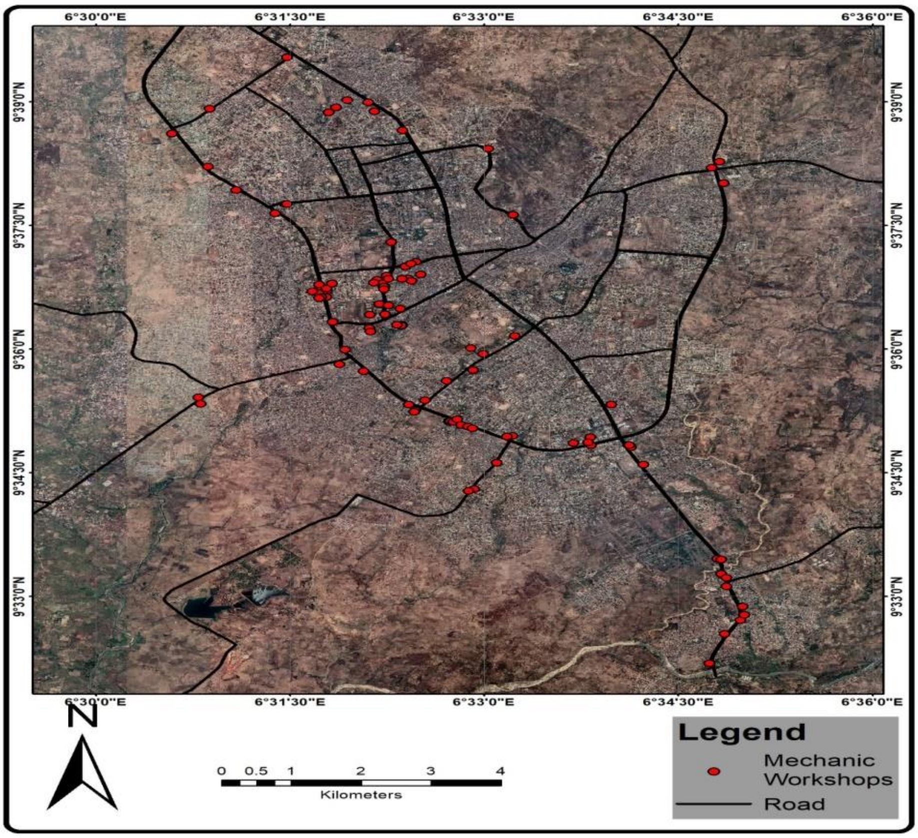


Figure 1: Spatial distribution of mechanic workshops in the study area
Source: Authors Fieldwork, 2021

Auto-Mechanic Workshop Operators and their Activities in Minna Metropolis

For the purpose of this study six (6) major auto-mechanic workshop selected out of 110 auto-mechanic workshops in Minna. The six (6), auto-mechanic workshop under study were; Bosso workshop, Northern Bye-Pass workshop, Abdulsalam Garage workshop, Ketere-Gwari workshop, Maitumbi workshop and Sarkin Pawa Auto Garage respectively. Also, their socio- demographic characteristics, activities, practices and attitudes were assessed. Ten (10) structured questionnaire was administered to each of the six (6) auto-mechanic operators and to understand the dynamics of their activities. Figure 4.2 revealed that the spatial distribution of the selected auto-mechanic workshop understudy.

Level of Soil Contamination in the Study Area

The soil quality test was carried out around the sample site within the study area, and compared with Federal Ministry of Environment in Nigeria (FMEnv), World Health Organisation (WHO), and NESREA threshold limits. The samples were collected from two depth of 0-15cm and 15-30cm and was subjected to analysis of its Physio-Chemical characteristics such pH, Conductivity, Organic Carbon, Total Nitrogen, Magnesium, Copper and Zinc to determine the level of soil contamination (see Table 4.1).

The study revealed that the soil pH level within the study area were slightly acidic to alkaline which ranged from 6.16-8.0. With electric conductivity ranges from 248.5-636 µs/cm. the study also revealed that the concentration of magnesium (Mg) recorded ranged from 0.80-13.0 mg/kg which were below the limit of 50 mg/kg. The concentration of copper (Cu) recorded within the study area ranged from 1.39-4.59 mg/kg, except at Northern bye-pass workshop and Sarkin-Pawa garage ranged 10.5 and 6.21 which is above the stipulated limit of 5mg/kg set by WHO/NESREA. The study revealed that zinc (Zn) concentration examined ranged from 2.44-7.79 mg/kg. While Northern bye-pass recorded Zinc concentration of 30.6 mg/kg which is above the standard set by WHO/NESREA of 10 mg/kg.

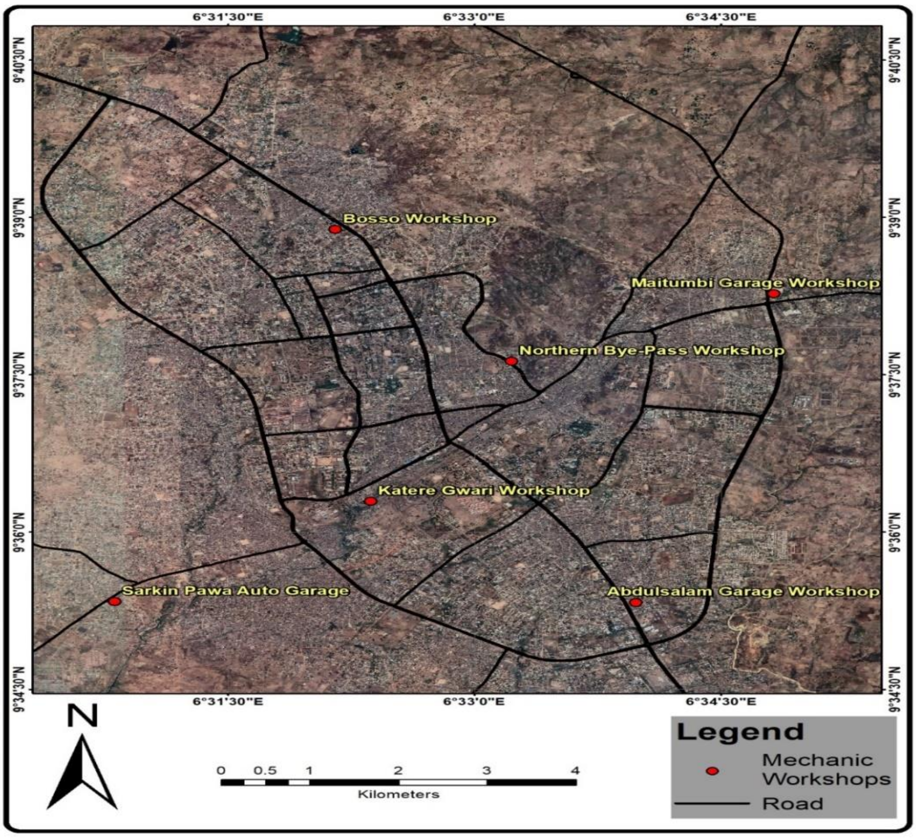


Figure 2: The six mechanic workshops understudied

Table 1: Physio -Chemical Quality of Soil in the Study Area

Parameters	**Units**	**The Study Area**						**WHO/NESREA Standards**
		Abdulsalam Garage	Bosso workshop	Katere Gwari workshop	Maitumbi Garage	Northern Bye-Pass workshop	Sarkin Pawa Garage	
pH		6.36	6.16	6.94	8.0	6.78	7.45	5.5
Conductivity	μs/cm	547.5	352	430	365	636	248.5	960
Organic Carbon	%	0.14	0.27	0.26	0.28	0.35	0.29	1.5-5.0
Total Nitrogen	%	0.07	0.14	0.15	0.14	0.2	0.21	10
Magnesium	mg/kg	0.91	1.33	13.0	1.38	0.80	1.15	50
Copper	mg/kg	4.59	3.55	5.23	1.39	10.5	6.21	5
Zinc	mg/kg	4.62	2.44	9.82	4.52	30.6	7.79	10

Discussion

From the study carried out revealed that there are 110 mechanic workshops in Minna. Out of six workshop that were sample shows that 67.1% of the auto-mechanic operators are involves in auto servicing and maintenance; 15% involved panel beating and welding services, 8.3% were involved in electrical re-wiring, 5% were involved in painting services, 6.7% were wheel balancing and 3.3% were involved battery charging services. The study revealed that type of waste generated were oil spills, grease, paint, fuel, metal scraps, battery and electrolyte.

The study revealed that the mean soil pH level for Abdulsalam garage were 6.36, Bosso workshop were 6.16, Katerin-Gwari workshop 6.94, Maitumbi garage were 8.0, northern bye-pass with pH level of 6.78 and Sarkin Pawa garage with pH level 7.45. The soil pH level within the study area is ranged from 6.16-8.0 which is above the recommended standard set by the WHO/NESREA. This implies that the soil pH level of all the mechanic workshop sampled were slightly acidic to alkaline. This could be as a result of the various activities carried out in the workshops such as, wielding, battery charging, panel beating, painting, auto engine servicing and repair. This supports the findings of Adelekan & Abegunde (2010), stating that activities within automobile workshop have the ability to affect the pH composition of the soil over a period of time.

The soil electric conductivity ranges from 248.5-636 µs/cm which were all below the recommended standard of 960 µs/cm. Also, organic carbon recorded ranged from 0.14-0.35% which is below the recommended limit of 960%. Total nitrogen recorded in all the sample location ranged from 0.07-0.21 which were below the 1.5-5.0 limit set by WHO/NESREA. The concentration of magnesium (Mg) recorded ranged from 0.80-13.0 mg/kg which were below the limit of 50 mg/kg. The concentration of copper (Cu) recorded within the study area ranged from 1.39-4.59 mg/kg, except at Northen bye-pass workshop and Sarkin-Pawa garage ranged 10.5 and 6.21 which is above the stipulated limit of 5mg/kg set by WHO/NESREA (see Table 4.1). This implies that that high concentration of copper in water leads to gastrointestinal disorder and high presence of chromium causes cancer (Aboud and Nasndini, 2009).

The study also revealed that Zinc (Zn) concentration examined ranged from 2.44-7.79 mg/kg. While Northern bye-pass recorded zinc concentration of 30.6 mg/kg which is above the standard set by WHO/NESREA of 10 mg/kg. This implies that the high concentration of zinc found at Northern bye-pass may be due to age of the mechanic workshops, volume of work done on each site, types of automobile service or repairs, type of lubricant commonly used, mode of wastes disposal and type of soil. This confirmed by Abenchi *et al.* (2010), increase level of Zn from auto mechanic workshop were attributed from activities such as lubricating oils, metals scraps, burning of tyres, welding and soldering.

Conclusion and Recommendations

The study was carried out to assess the environmental impact of the activities of Auto-Mobile (Mechanic) Workshop on soil quality in Minna. The study revealed that most of the mechanic workshop activities constituted to the pollution of the soil air quality of the area, while some of some of the pollutants are recorded to be far higher that recommended limits set by WHO/NESREA and study found that there is high presence of heavy metals on the soil within and around the study area which might pose serious health effects on the residents if adequate measures is not put into place. The study recommend that special chambers should be created within the workshops to reduce the contamination of heavy metals on the soil. The study also recommends environmental impact assessment be carried out in all mechanic workshops in Minna to have first-hand information in order to ascertain the level of soil pollution.

Reference

Abidemi, O. O. (2011). Levels of Pb, Fe, Cd and Co in soils of automobile workshop in Osun State, Nigeria. *Journal of applied sciences and environmental management*, *15*(2).

Adelekan, BA A. & Abegunde, K. D (2011). Heavy metals contamination of soil and groundwater at automobile mechanic villages in Ibadan, Nigeria. *International Journal of Physical Sciences*, *6*(5), 1045-1058.

Adewoyin, O. A., Hassan, A. T., & Aladesida, A. A. (2013). The impacts of auto-mechanic workshops on soil and groundwater in Ibadan metropolis. *African Journal of Environmental Science and Technology*, *7*(9), 891-898.

Balasubramanian, M. (2019). Economic value of regulating ecosystem services: a comprehensive at the global level review. *Environmental monitoring and assessment*, *191*(10), 1-27.

Demie, G. (2015). Analyzing soil contamination status in garage and auto mechanical workshops of Shashemane City: implication for hazardous waste management. *Environmental Systems Research*, *4*(1), 1-9.

Doran, J. W., & Parkin, T. B. (1994). Defining and assessing soil quality. *Defining soil quality for a sustainable environment*, *35*, 1-21.

Fayiga, A. O., Ipinmoroti, M. O., & Chirenje, T. (2018). Environmental pollution in Africa. *Environment, development and sustainability*, *20*(1), 41-73.

Ibrahim, D., Abdullahii, S. U., Adamu, I. U., Dazi, L. L., Salihu, A. I., and Simon, I. A. (2019). Heavy metal contamination of soil and ground water at automobile mechanic workshops in Borno State, Nigeria. Nigerian Research Journal of Chemical Sciences, 7, 197 – 213.

Jia, L., Wang, W., Li, Y., & Yang, L. (2010). Heavy metals in soil and crops of an intensively farmed area: a case study in Yuncheng City, Shandong Province, China. International journal of environmental research and public health 7(2), 395-412.

Jolaoso, A. O., Njoku, L. K., Adedokun, A. H., & Adesuyi, A. A. (2019). Assessment of Automobile Mechanic Workshop Soils in Lagos and the Genotoxic Potential of the Simulated Leachate Using Allium Cepa L.

Mani, D., & Misra, S.G. (2009). Soil pollution.

Nebo, C. U., Udom, G. J., & Ehirim, C. N. (2018). Contaminant impact assessment of automobile mechanic workshop on soil and groundwater resource in Port Harcourt, Nigeria. *International Journal of Science Inventions Today*, *7*, 451-463.

Pam, A. A., Shaâ, R., & Offem, J. O. (2013). Evaluation of heavy metals in soils around auto mechanic workshop clusters in Gboko and Makurdi, Central Nigeria. *Journal of Environmental chemistry and ecotoxicology*, *5*(11), 298-306.

Parikh, S. J., & James, B. R. (2012). Soil: the foundation of agriculture. *Nature Education Knowledge*, *3*(10), 2.

Utang, P. B., Eludoyin, O. S., & Ijekeye, C. L. (2013). Impacts of automobile workshops on heavy metals concentrations of urban soils in Obio/Akpor LGA, Rivers State, Nigeria. *African Journal of Agricultural Research*, *8*(26), 3476-3482.

SUB-THEME 5:
SUSTAINABLE COST MANAGEMENT OF BUILT ENVIRONMENT PROJECTS IN THE ERA OF COVID-19

Impact of External Pressures on Adoption of BIM in Construction Organisations

Sani, S.N.[1], Nasir, R.M.[2], Abdullahi, A.M.[3] & Jibril, U.S.[4]
Department of Quantity Surveying, Ahmadu Bello University, Zaria, Nigeria
nurudynsani@gmail.com[1], rashmaiturare@gmail.com[2], madugu@graduate.utm.my[3], & jibrilusman21@gmail.com[4]

***Abstract**:*
Building Information Modelling (BIM) is relatively complex and influential innovation in the architecture, engineering, and construction (AEC) industries. This research studied the impact of three types of external pressures (i.e., coercive, mimetic, and normative pressures) on adoption of building information modelling (BIM) in construction organisations. The effects of these pressures are empirically tested with survey data collected from 39 BIM based construction organisations and BIM oriented organisation. The results from partial least squares analyses showed that coercive and normative pressures both significantly influenced the organisations on BIM adoption. This study supports that the construction organisations BIM adoption is complex socialized activity that is not only motivated by the types of projects or size of the organisations, but also driven by the influence of the external pressures.

Keywords: Building Information Modelling (BIM), External Pressures, Innovation adoption, Construction organisation

Introduction

The construction industry is complex and dynamic in it nature. The industry entails many players (e.g., architects, builders, contractors, engineers, clients, quantity surveyors, etc.) at various stages such as planning, designing, construction, maintenance, etc. The construction industry has become very complicated given the political and business trends that are exerting additional economic pressure. Owing to the complexity of the construction industry, it faces several challenges such as low productivity, poor quality work, poor rising cost, excessive construction waste, delays and lack of information sharing among project stakeholders (Kaleem et al., 2019). For a while, the construction industry has been criticised for being reluctant to adopt innovative technologies that enhance their relatively poor production performances (Dongping, Heng, & Guangbin, 2014). Christopher (2017) revealed that construction industry has lower rate of adoption of innovation than other industries despite being described as "a lively source of new ideas".

However, US National BIM Standards (NBIMS) defined Building Information Modelling (BIM) as a "digital representation of physical and functional characteristics of a facility creating a shared knowledge resource for information about it forming a reliable basis for decisions during its life cycle, from earliest conception to demolition." (NBIMS, 2007). While Kymmell (2008) defined Building Information Model as a project simulation consisting of the 3D models of the project components with links to all the required information connected with the project's planning, construction or operation, and decommissioning.

Building Information Modelling (BIM) is a revolutionary innovation in the construction industry to virtually design and manage projects throughout the projects lifecycle (Kaleem, Irene, & Emlyn, 2019). Even though BIM has been adopted in the construction sector over the last two decades and it has the capacity to transform and enhance performance by decreasing inefficiencies, improving productivity and increasing collaboration among project stakeholders (Armstrong, Wright, Ashe, & Neilson, 2017). Adoption of BIM offers the visualization of design, fast creation of alternative designs, automatic examination of model reliability, production of reports and building performance forecasting (Sacks et al., 2010). Despite the potential benefits of BIM, its implementation rate has been slow owing to various barriers (Walasek and Barszcz, 2017). Construction Industry Development Board reported that the slow level of transformation towards BIM could be due to the lack of standardized BIM process and the absence of guidelines for its implementation (CIDB, 2013).

Although research indicates that innovation adoptions in construction industry are not only motivated by efficiency need to address internal process problems but also influence by external pressure from environment (Bossink, 2004; Mitropoulos and Tatum, 2000). The organizational responds to external pressure in adoption of any innovation is highly depended to it characteristics and industry attributes (Bhakoo and Choi 2013). Meyer and Rowan (1977) described institutional rules as myths that organizations incorporate and use to gain validity, resources and stability, and enhance their prospects of survival. Institutional isomorphism, as a basic tenet of institutional theory, refers to the tendency for an organization to follow socially accepted norms and behaviours in order to be structurally congruent with their specific institutional environment (Dongping, Heng, & Guangbin, 2014). Scott, (2001) argued that external pressures can originate from both formal rules (regulations, mandates) and informal constraints (norms, conventions, beliefs), and how organizations respond to these pressures will determine their institutional legitimacy. According to DiMaggio & Powell, (1983), there are three basic types of isomorphic pressures shaping organizational behaviours: coercive, mimetic, and normative.

Dongping, Heng, & Guangbin, 2014) studied the impact of isomorphic pressure on BIM adoption in particular construction project in China. Donya (2016) explored the adoption of BIM in the United Arab Emirate (UAE) construction industry looking at authority command on implementation of BIM in public construction project by Dubai Municipality (DM) on buildings over forty (40) stories followed by mandate in the UK in public sector projects by 2016.

Meanwhile, the empirical evidence established from literature explored the impact of institutional pressure (isomorphic pressure) on adoption of BIM was on construction project (Dongping, Heng, & Guangbin, 2014). Though, the adoption of BIM can be done at three levels; Industry, Organisation and Project level (Jung & Joo, 2011). Therefore, this study assessed the impact of external pressures on adoption of building information modelling (BIM) in Construction organisations.

Research Method

This study adopted the quantitative approach. Quantitative research is implemented in cases where it is important for a researcher to have statistical conclusions to collect actionable insights. Numbers provide a better perspective to make important decision through analysis. Quantitative approach is also important for research that needs to have a statistical conclusion (which is applicable to this study), because any conclusion drawn on the basis of numbers and analysis will only prove to be effective for the research (Fellow & Liu, 2015).

This research variable was obtained from literature review, to gain the general overview of BIM and identify the external pressures impacting BIM adoption in the construction industry. The external pressure variables identified through review were subsequently used for the preparation of questionnaire administered online. Questionnaire designed into two major sections (Section A and B). Section 'A' was used to obtain information regarding the respondents and their organisations profile. This is basically to obtain an insight to the validity and reliability of responses provided by the respondents. They information were; The types of organisations, Position of the respondent, Years of experience, the usage of BIM by the organisation and the level of usage.

In section 'B' the respondent was requested to rate the impact of external pressures on adoption of BIM based on a 7-point Likert scale. where; 1= 'No impact' 2= 'Low impact' 3= 'Somewhat Impact' 5= 'Moderate Impact' 6= 'High Impact' 7= 'Extremely Impact'.

The research adopted descriptive method because of it descriptive nature. Cross-sectional survey research design was also adopted to gather responses from the targeted respondents which was used to assess the impact of external pressure on adoption of BIM in Nigerian construction organisation.

Research population is generally a large collection of individuals or objects that is the main focus of scientific query. Target population refers to the entire group of individuals or object to which the researchers are interested to generalizing the conclusion. The study population for this research are construction professionals from selected states of Nigeria (Lagos, Kaduna, Kano and Abuja) who are knowledgeable on BIM adoption.

Sampling method is the process of selecting a few numbers from a bigger group which will be used as a basis for estimating or predicting the prevalence of an unknown piece of information, situation or outcome regarding the bigger group (Ranjit & Kumar 2005). A sample therefore is representative of sub group of the population one is interested in.

As the adoption of BIM is still relatively rare among Nigerian construction organisations, a completely random sampling method could not be used to elicit cases from a specific organisation database (Dongping, Heng, & Guangbin, 2014). Snowball sampling is a non-probability sampling design which may involve data which are difficult to access, perhaps because the individual sources of data cannot be identified readily; alternatively, snowball sampling is used to collect data when the population is difficult to reach or hidden – in such circumstances, a sampling frame is infeasible. In such situations, the researcher may identify a (very) small number of sources (respondents: 'seeds') and, after collecting data from each one, requests that source to identify further sources, thereby progressively building a sufficient sample (Fellows and Liu, 2015). Instead, different BIM oriented organisations were identified through variety methods, such as by contacting professionals whom have knowledge on BIM and BIM oriented organisations, LIKE-IN BIM professional group and industry publications. Therefore, a snowball sampling technique was utilised to identify the respondents that are appropriate for this study.

The objective of sampling is to provide a practical means of enabling data collection process to be carried out while ensuring that sample provides good representative of the population (Fellows & Liu, 2015). The sample frame of this research is architectural, Quantity surveying, Mechanical. Electrical and Civil Engineering organisations.

Sample sizes are determined by the confidence level required of the estimator. The unknown mean of a population can be estimated with a predetermined level of confidence (Fellows & Liu, 2015). Sample size refers to the number of participant or observation included in a research study to represent a population. A total number of 39 respondents were used for this research.

Data collected from identified respondents was analysed and presented using descriptive and inferential analysis using SPSS (version 26) and SmartPLS 3.0. Regression analysis was also used in this study. It was considered in expressing the relationship between two variables. One or more known values, realisation of the independent variable; and other unknown, the dependent variable (Fellows & Liu, 2015).

Results and Discussion

This chapter is mainly on data presentation, analysis and discussion of result. An online questionnaire was administered and shared to the targeted respondents in referral processes to get access to more respondents (snowballing method). The total number of 39 responses were obtained from the field survey and are simultaneously used for the analysis.

Characteristic of the Respondents

From Table 1. The findings showed that 43.6% of the respondents are from Architectural organisation, 2.6% from Building, 28.2% from Quantity Surveying, 5.1% from Civil Engineering 10.5% from Mechanical Engineering and Electrical Engineering. It also reveals that 48.7% of the respondents occupied the top management positions in their organisation, 38.5% of middle management level and 12.8% low management level.

Table 49: Demographic Characteristics of The Respondents

S/N	Variables	Categories	Frequency (NO)	Percentage (%)
1	Type of Organisation	Architecture	17	43.6
		Building	1	2.6
		Quantity Surveying	11	28.2
		Civil Engineering	2	5.1
		Mechanical Engineering	4	10.3
		Electrical Engineering	4	10.3
2	Position of the respondents	Top management	19	48.7
		Middle Management	15	38.5
		Lower management	5	12.8
3	Years of Experience	Less than 5yrs	6	15.4
		5-10yrs	13	33.3
		10-15yrs	10	25.6
		15 and above	10	25.6
4	Adoption of BIM in Organisation	YES	2	5.1
		NO	37	94.

Furthermore, the table depict that 15.4% of the respondents had less than five years of experience, 33.3% had between five to ten years, 25.6% had ten to fifteen years and 25.6% fifteen years and above. Similarly, the table shows only 5.1% of the respondent adopted BIM in their construction organisation while 94.9% of the respondents haven't adopt BIM in their organisation. However, the findings show that Architectural and Quantity Surveying organisation has the highest percentage of the response and more than 85% of the respondents were at strategic managerial positions as well as about 63.1% of the respondents had more than five years of experience in construction organisation.

Data Presentations and Results

Partial least square (PLS) is a components-based structural equation modelling (SEM) technique, was used to validate the results. SmartPLS 3.0 software was employed to run the PLS analysis. PLS allows for simultaneous estimation of multiple dependent variables and thus is well suited for the assessment of mediation effects (Cao *et., al.*, 2016) PLS's ability to analyse research models with single-item constructs (Ringle *et. al.* 2012) makes it particularly appropriate as an analytical tool for this study.

Reliability Test: Internal Consistency Test

According to Foster (2011), reliability refers to the consistency of results among various items in a test. This research used Cronbach alpha to verify the internal consistency among the pressures exalted on organisations in adoption of BIM. The coefficient is used to determine whether a questionnaire measures the impact external pressures on adoption of BIM are related to each other. As reported in Table 2: The pressures were subjected to an internal consistency analysis using reliability analysis. Nunnally (1978) recommended using a minimum Cronbach's alpha value of 0.7.

Table 50: Internal consistency analysis: Reliability test

Variables	Cronbach's Alpha of the Items
Government policy enforcement	0.900
Professional regulatory body introduction	0.890
Adoption because another organisation benefitted	0.887
Adoption because other organisation gained reputation	0.881
Adoption because other org perceived favourably by others	0.878
Adoption because of software vendors advocacy	0.879
Adoption because of industry consultant's advocacy	0.869
Adoption because of academic institutions advocacy	0.876
Adoption because of industry associations strongly propagation.	0.886

The Cronbach 's alpha value for this analysis all exceeds 0.7, indicating that all pressures exhibited

high internal consistency and that the questionnaire was thus reliable (Netemeyer, 2003). However, Table 3 shown the summary of the Cronbach's alpha used for the analysis in this research.

Table 51: Summary of Cronbach's Alpha

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.883	0.880	9

Measurement Validation

The validity of the measurements was assessed in terms of internal consistency, convergent validity, and discriminant validity. Internal consistency was assessed through the estimate of composite reliability. Convergent validity measures the extent to which the items underlying a particular construct actually refer to the same conceptual variable. The first evidence of convergent validity is provided by the values of average variance extracted (AVE). As shown in Table 4.4, each AVE is above the threshold of 0.5, indicating that at least 50% of the variance in the items can be accounted for by their respective construct. Further evidence of convergent validity is obtained by estimating the factor loadings of the measurement items. The standardized factor loadings of the items on their respective constructs are all above the threshold of 0.7 and are significant, and there exists no cross-loading problem (Table 3). Also, it is shown that the square roots of the AVE (values on the diagonal of the correlation matrix in Table 4) are all greater than the absolute value of interconstruct correlations, suggesting that the constructs possess satisfactory discriminant validity.

Table 52: Measurement of Items and Loadings

Code	Items	Item Loadings			
		CP	MP	MP	Mean
CP1	Government policies enforcing our organisation to adopt BIM	**0.968**	0.343	0.311	1.97
CP2	Professional regulatory body instruction on use of BIM in our organisation.	**0.722**	0.365	0.584	2.64
MP1	Adoption of BIM because other peer organisation benefitted from it.	0.42	**0.875**	0.512	3.15
MP2	Adoption of BIM because peer organisation that adopt it gained reputation in the industry.	0.31	**0.906**	0.613	3.10
MP3	Adoption of BIM because other peer organisation perceived favourably by others in the industry	0.239	**0.786**	0.724	3.46
NP1	Adoption of BIM because of Software vendors advocacy on it.	0.394	0.581	**0.774**	3.03
NP2	Adoption of BIM because of Industry consultant's advocacy on it.	0.514	0.608	**0.907**	3.08
NP3	Adoption of BIM because of academic institutions advocacy on it.	0.432	0.557	**0.922**	3.15

NP4	Adoption of BIM because Industry associations strongly propagate the value of BIM in our types of organisations.	0.121	0.656	**0.748**	3.33

Note: Bold values represent standardized factor loadings of the items on their respective constructs.

CP = coercive pressures; MP = mimetic pressures; NP = normative pressures.

Table 53: Measurement Validity and Construct Correlation

					Correlation Matrix[b]		
Construct	Mean[a]	SD	CR	AVE	CP	MP	NP
Coercive Pressures (CP)	4.62	2.64	0.841	0.729	**0.852**		
Mimetic Pressure (MP)	9.72	5.11	0.892	0.735	0.751	**0.857**	
Normative Pressure (NP)	12.59	7.09	0.906	0.707	0.5	0.778	**0.84**
BIM Adoption	Na	na	Na	na	0.68	0.862	0.793

Note: SD = standard deviation; CR = composite reliability; AVE = average variance extracted.

[a]Arithmatic means, different from the factor scores used in the PLS analyses.

[b]Bold values on the diagonal represent the square root of AVE.

na= Not Applicable.

Result of PLS Analysis for the Research Model

The result shows the statistical significance of path coefficients. The results of the PLS algorithm analyses are presented in Fig. 1. The R- square value of the dependent variable, BIM adoption by the construction organisation, is 0.111, suggesting that relatively substantial variances in the construct are explained by the research model. It also shows the influence of external pressure on BIM adoption is significant. It is also shown that the Coercive Pressure-Organizational BIM adoption link (C= 0.237, $p < 0.05$) and the Mimetic Pressure- Organizational BIM adoption link (M= -0.318, $p < 0.05$), and the Normative Pressure-Organizational BIM adoption link is found to be (N= 0.172, $p > 0.05$) respectively. These indicates that, the link between coercive and normative pressures are significant while nonsignificant in the case of mimetic pressures. The results further indicate that although both the influences of CP and NP on Organisation are significant, the influence of CP is much stronger than that of NP.

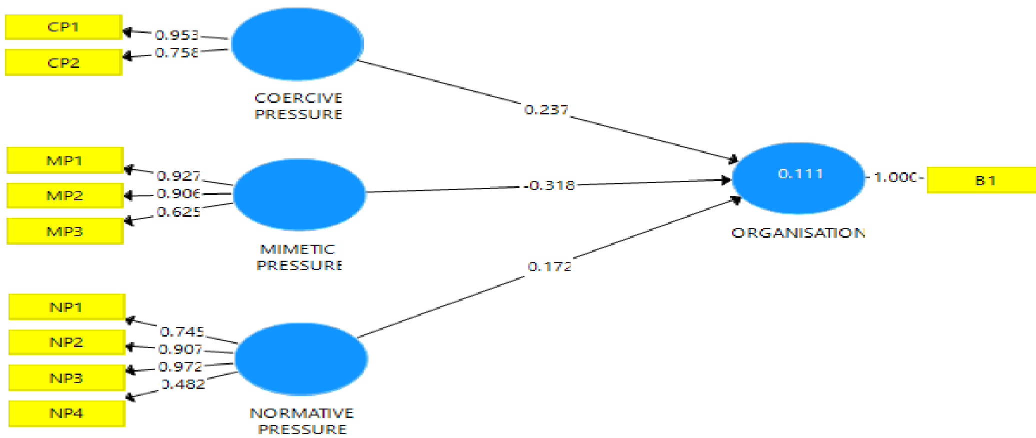


Figure 3: Results of PLS analyses for the research model

One-way ANOVA was carried out to compare the means organisations (Architects, Quantity surveying, Engineers and builders) on the impact of external pressures on adoption of BIM on construction organisation as shown in Table 6 above.

Table 54: ONE WAY ANOVA

ANOVA						
		Sum of Squares	Df	Mean Square	F	Sig.
Mean of coercive pressure	Between Groups	7.916	5	1.583	1.251	0.308
	Within Groups	41.777	33	1.266		
	Total	49.692	38			
Mean of Mimetic pressure	Between Groups	20.721	5	4.144	1.711	0.160
	Within Groups	79.945	33	2.423		
	Total	100.667	38			
Mean of Normative pressure	Between Groups	25.458	5	5.092	2.589	0.054
	Within Groups	64.901	33	1.967		
	Total	90.359	38			

Discussion of Results.

The objective of this research is to assess the impact of external pressures in construction organisation on BIM adoption activities. Overall, the results provide evidence that the quest for acquiring institutional legitimacy plays an important role on organisations in BIM adoption processes, and external pressures as a whole can significantly influence the BIM adoption in construction organisation. Through such a validity acquiring process, however, different types of external pressures evident themselves in relatively different ways.

Coercive pressures are found to be significant influencing factors for organisation to adopt BIM. It is also found that the influence of coercive pressures on organisations was much stronger than those of two other types of external pressures. Although some prior research in other industries reveals that external mandates may not significantly influence innovation adoption activities, or may only result in some ceremonial changes (Barratt and Choi 2007), the influence of coercive pressures on BIM adoption examined in this study seems to be more substantial. This is probably because at present coercive pressures are principally exerted on organisations that mostly partake in large construction project (as shown in Table 5, the overall level of perceived coercive pressures is quite low, with a mean value of 4.62).

The relationship between mimetic pressures and BIM adoption by the organisation is also found to be statistically nonsignificant. Prior studies on adoption of BIM on construction project examined the influence of mimetic project significant (Cao *el., al.* 2016). Also, other construction innovations have also examined the influence of mimetic pressures on innovation adoption intentions or behaviours, and have suggested relatively conflicting results. Esmaeili and Hallowell's (2012) study on administrative safety innovations in the United States and Kale and Arditi's (2005) study on CAD technology in Turkey indicate that imitative behaviour is the primary reason for the diffusion of these innovations. This study further shows that the influence of mimetic pressures on BIM adoption is partially mediated by competencies of the organisations and the types of projects they are mostly engaged on it. These findings indicate the level perceived by the peer organisation the certainties and uncertainties of BIM adoption is relatively high (Table 5. mean= 9.72). This probably reflects those benefits, gaining reputations or favourable by other in industry among many organisations are not driven factor by peer organisations on BIM adoption.

However, in the case of normative pressures, this study provide evidence that shows a significant influence on organisation in BIM adoption. This research also follows the train of some prior researches indicates that participants in the construction industry often rely on the information provided by outside professionals to determine whether or not to adopt innovations (Toole 1998). Even though (Cao *et., al.* 2016) in his findings shows nonsignificant influence of normative pressures on BIM adoption in construction projects. Furthermore, the impact of normative pressure on organisation of BIM is probably because professional communities have exerted enough effort to promote the use of BIM through software vendors' advocacy, industry consultant advocacy, academic institution advocacy and industry associations as the collected data also reveal that the average level of perceived normative pressures in the surveyed organisation is very high (Table 5, mean 12.59).

Conclusion

Construction industry is characterized as relatively complex and dynamic industry. The industry was also being criticized for being reluctant adopting innovations compared to other industry or sectors such health, education, agriculture etc. BIM is the leading and current innovation presently available in construction industry. Its captured increasing interest among industrial and academic circles in recent years, but its diffusion in the construction industry worldwide is still at a relatively initial stage. From an institutional theory perspective, this paper developed and empirically tested a research model to explain how three different types of external pressures influence the behaviours of construction organisations on BIM adoption. Generally, PLS analyses based on the data collected from 39 construction organisations and BIM oriented professionals provide evidence that external pressures as a whole can significantly influence the BIM adoption by construction organisations. The findings suggest that the organisations adopt BIM were not only motivated by rationale needs to improve the efficiency and effectiveness in executing their professional competencies, but also driven by external pressures.

References

(NBS), N. B. (2013). National BIM report 2013. *NBS National BIM Library.* Newcastle upon Tyne, U.K.

Abdullahi, A. M. (2015). Modelling the Information Requirement for Building Information Modelling (BIM)- based Quantity Take-off. *Unpublished Thesis*.

Abdullahi, M., Ibrahim, Y. M., & Ibrahim, A. D. (2014). Assessing Contractors Cash Flow Forecasting Capalities. *Paper presented at the 3rd NMMU Construction Management conference Port Elizabeth South Africa*.

Ahmed, O., Owolabi, A. H., & Oladimeji, A. O. (2020). Big data innovation and difffusion in projects team: Towards a complict preventive culture. *Developments in the Built Environment*.

Armstrong, A., Wright, C., Ashe, B., & Neilson, H. (2017). Enabling innovations in building sustainability: Australia's National Construction Code. *Pocedia Engineering*, 320-330.

Azhar, S. (2012). Building Information Modelling (BIM): Now and Beyond. *Australian Journal Construction Economics and Building*, 15-28.

Azhar, S., Carlton, W. A., Olsen, D., & Ahmad, I. (2011). Building in formation modelling for sustainable design and LEED rating analysis. *Autom. Contr*, 20(2), 217-224.

Bhakoo, V., & Choi, T. (2013). The iron cage exposed: Institutional pressures and heterogeneity across the healthcare supply chain. *J. Oper. Manage*.

Bossink, B. (2004). Managing drivers of innovation in construction networks. *J. Constr. Eng. Manage*, 337-345.

Carlos, A. S. (2007). Isomorphic Institutionalization and Legitimacy: Operational Auditing at the Court of Auditors. *Brazillian Administration Review*, 35-50.

Cartlidge, D. (2011). New Aspests of Quantity Surceying Practice. *Oxon: Spon Press*.

DiMaggio, P. J., & Powell, W. W. (1983). The iron cageb revisited: institutional isomorphism and collective rationality in organisational fields. *Am. Social. Rev*, 48(2), 147-160.

Dongping, C., Heng, L., & Guangbin, W. (2014). Impacts of isomorphic pressures on BIM Adoption in Construction Projects. *J. Constr. Eng. Manage.*, 140.

Dossick, C., & Neff, G. (2010). Organisational division in BIM-enabled commercial constrcution. *J. Constr. Eng. Manage*.

Eastman, C., Teicholz, P., Sacks, R., & Lisbon, K. (2011). BIM hanbook: Aguide to building information modelling for owners, managers, designers, engineers and contrcators 2nd Ed. *John Wiley & Sons, Hoboken, NJ*.

Esmaeili, B., & Hallowell, M. (2012). Diffusion of safety innovations in the construction industry. *J. Constr. Eng. Manage*, 955-963.

Kaleem, U., Irene, L., & Emlyn, W. (2019). An Overview of BIM Adoption in the Construction Industry: Benefits and Barriers. *Emerald Reach Proceedings Series*, Vol. 2 pp. 297-308.

Kymmell, W. (2008). BIM: Planning and managing Construction Project with 4D CAD and Simulations. *United State of America: McGraw-Hill Companies*.

Lee, G., Lee, J., & Jones, S. A. (2012). The business value if BIM in south Korea. *McGraw Hill Construction, Bedford MA*.

Liliana, M., Cardona, M., Manuela, P. D., Maria, d. S., & Angels, D. C. (2020). The Institutional Isomorphic in the Contex of Organisation Changes in Higher Education Institutions. *International Journal of Research in Education and Science (IJRES)*, 6(1), 61-73.

Markus, S., Moritz, A., & Phillip, P. (2019). Institutional Isomorphic, enterpreneuship and effectiveness: the adoption and implementation of quality management in teaching and learning in germany. *Tertiary Education and Management*, 25: 115-129.

Nunnally, J. C. (1978). *Psychometric theory, 2nd Ed.* New York: McGraw-Hill.

Rachel, A., George, B., & Rick, D. (2020). Escape from the iron cage? Organisational Change and isomorphic pressures in the Public Sector. *Public Management Research Association*, 165-187.

Rafael, S., Mark, G., & Ioannis, B. (2020). Building Information Modelling, Artificial Intelligence and Construction Tech. *Development In the Built Environment*.

Saurav, D., Anna, S., Adam, M., & Priyanka, S. (2020). Study of enabling factors affecting the adoption of ICT in the Indian Built environment Sector. *Ains Shams Engineering Journal*.

Scott, W. R. (2001). Institution and organisations, 2nd Ed. *Sage Publications, Thousand Oaks, CA*.

Smith, P. (2014). BIM Implementation-Global Strategies. *Creative Construction Construction*.

Song, W. G. (2014). A Technical Review of BIM Based Cost Estimating in UK Qunatity Surveying Practices, Standard and Tools. *Journal of Information Technology in Constrction*, 19, 534-538.

Succar, B. (2009). Building Information Modelling Framework: A research and delivery foundation for industry stakeholders. *Autom Constr*.

Yahaya, M. I., & Muhammad, A. (2016). Introductionto Building Information Modelling. *Annual General meeting of the Nigerian Institute of Quantity Surveyors.* Port-Harcourt.

Assessment of Project Financing Options by Construction Micro, Small and Medium Enterprises in Nigerian Construction Industry

Yesufu, S.I.[1a], Musa-Haddary, Y. G. [2], Gandu, J. Y. [3], Abdullahi, I. [4], & Momoh, N.[1b]
[1]Department of Quantity Surveying, School of Environmental Studies, Auchi, Polytechnic, Auchi
[2]Department of Quantity Surveying, Ahmadu Bello University, Zaria, Kaduna State
[1a]yusufshehu5@gmail.com; [2a]gmusahyddary@gmail.com; [2b]yusufgandu@yahoo.com; [2c]abdullahi@hotmail.com; [1b]nuramaster@gmail.com
Corresponding author: yusufshehu5@gmail.com

***Abstract*:**

Globally, construction industry is the backbone of both emerged, transition, and emerging nations' economies activities particularly Africa in which Nigeria belong. In spite of its numerous importance on the national economy, it is saddled with numerous financing challenges. This study assessment of project financing options by construction micro, small and medium enterprises MSMEs in Nigerian construction industry. These options were identified from intensive literature review and were grouped into six (6) main sources required as components to develop a framework for the selection of appropriate project financing options for construction MSMEs with a view to determining the most suitable options for construction MSMEs selection of suitable project financing options toward effective participation and performance. Data were collected using semi-structured questionnaires. A total of three hundred and sixty-three (363) questionnaires were distributed randomly to some selected construction MSMEs. Two hundred and nineteen (219) questionnaires were received valid and suitable for analysis. Descriptive and inferential statistical methods were used via statistical package for social science 24 and micro soft excel software to determine the most salient factors. It was revealed that overdraft and term loan are familiar with construction Micro and small enterprises, while, the construction medium enterprises are mostly familiar with overdraft. These are among project financing options to be included in a framework for construction MSMEs selection of appropriate PF options for effective performance participation towards improving success rate in Nigerian construction industry, built environment and for sustainable development in COVID-19 era.

Keywords: Construction Industry, Project, Financing, Emerging Economies and Performance

Introduction

Construction industry both in emerged, transition and emerging nations' economies globally experienced relatively high proportion of business failure in construction sectors particularly African in which Nigeria belong (Fang & Cong, 2014; Yan, Chong, Sheng & Wang, 2017; Abdullahi, 2018). This often times resulted to poor finance performance challenges among others (Baños-Caballero & Martínez-Solano, 2016; Abbasi, Wang & Abbasi, 2017). Due to inadequacy of internal sources of finance, the use of external finance sources become imperative and construction MSMEs are face with the challenges of selecting appropriate Project Financing PF options (Tang & Wong, 2010; Wang, 2017). Therefore, construction MSMEs must undertake regular appraisal and assessment of their finances, efficient book-keeping, and loan accessibility to enjoy creditworthiness in order to enhance their access to finance for expansion, growth and business management performance (Gambo, Said & Ismail; Onwuamaeze, 2021).

Researchers advocated for a framework to aid construction MSMEs selection of appropriate PF options (Harrison & Baldock, 2015; Gambo et al., 2016; Kumar & Rao, 2016) to enjoy creditworthiness, expansion growth, cash flow for the purchase of new and maintenance of old equipment for construction projects execution. Construction MSMEs in Nigeria are officially classified by National Bureau of Statistics (NBS) and Small & Medium Enterprises Development Agency of Nigeria SMEDAN (NBS & SMEDAN, 2012) as: Micro enterprises: refers to construction enterprises whose number of employees does not exceed thirty

(30); Small construction enterprises are those whose number of employees are between thirty-one (31) and seventy (70), while the Medium construction enterprises are those whose number of employees are from seventy–One (71) to two hundred (200) employees.

Abdulsaleh & Worthington (2013); Ayirebi et al. (2017) posit that construction MSMEs play a crucial role in both emerged and emerging economies as the engine propeller of innovations, wealth creation, poverty reduction, employment generation, and creation. Functioning as a catalyst for economic growth and backbone for development (Abor & Quartey, 2010; Kuruppu & Azeez, 2016; Arthur-Aidoo *et al*., 2018). Despite their huge relevance, the management of construction MSMEs has not achieved the expected success in PF selection sustainable built environment towards post pandemic era and adoptability. Construction MSMEs in emerged, transition and emerging economies, particularly Africa in which Nigeria belong, should be able to select, easily from the numerous PF options, most appropriate for construction MSMEs business (Abor & Quartey, 2010**;** Bosede et al., 2016; Yan et al., 2017). However, this is hardly the case as these construction MSMEs appear not to have any standard template that guides their selection from the available PF options (Rodrick, 2010; Harrison & Baldock, 2015; Kumar & Rao, 2016). This can be attributed to lack of a framework to guide construction MSMEs selection process from the numerous PF options; therefore, it requires improvement.

Inadequate financing resulted in poor business performance and eventually business collapses and failure (Nwanyanwu, 2014; Baños-Caballero & Martínez-Solano, 2016). A selection toolkit with the potential of improving performance of construction MSMEs participation in PF has been identified as very needful and demanded by scholars (Kuruppu & Azeez, 2016; Kumar & Rao, 2016; Wang, 2017; Ali et al., 2019) has finances being identified as the central pillar of all business, including construction MSMEs (Aruwa, 2006; Ayodele, 2016; Osmond & Paul, 2016; Ali et al., 2019). The study seeks to assess PF options by construction MSMEs to improve their performance in the Nigerian construction industry. The objectives set out to achieve the research aim are to: identify various PF options available for construction MSMEs, assess various PF options by construction MSMEs and determine the most suitable PF options available for construction MSMEs in Nigerian construction industry. The paper reviews literature, research method, data analysis and findings; conclusion and finally recommendations.

Review of Related Literature

Construction SMEs financing is of vital interest to academics, construction SMEs and practising managers in various industries, particularly in transition and emerging nation's economies around the world. Construction SMEs serve as the engine of development, generation and creation of employment, and the bedrock of any nation economy. Consequently, financial managers at all levels in every organisation must decide when, where, from and how to acquire monies needed to meet their investment requirements. Once the financial manager is able to determine the best financial mix raise the appropriate amount through the best available sources. Basically, there are two major types of financing sources that are most crucial to any form of business particularly construction SMEs financial decision making. Construction SMEs can effectively and efficiently raise finance through: formal (internal) and informal (external) sources.

Internal Sources:

This comprise of retained earnings, capital reserves, capital surplus, sinking fund (March, 2016; Ojha & Pandey, 2017), vendor financing of equipment (Nevitt & Fabozzi, 1998), disposal of assets (Sales), contingency fund, services (contract on agreed price over a fixed period of time) and cash inflow (income) (Kenley, 2003; Hassanein & Adly, 2008).

External Sources:

Forty-Eight (48) PF options were identified through intensive literature review and were categorised into the following sub-headings namely: Financial Institutions; Micro finance, Commercial, Merchant, and Development Banks and Fund/Multilaterals Institutions, Modern Construction SMEs PF Arrangement, World Bank and Related Sources of Finance, Traditional financing options, Government financing arrangement and Islamic banking (Interest – free Loans).

Financial Institutions, Micro finance, Commercial, Merchant, and Development Banks

These form of PF sources available to construction SMEs include: (Debt borrowing), Micro finance, commercial, merchant, Federal mortgage Bank (FMB), Deposit Money Bank (DMB) and Investment bank or other financial institutions, and borrowing by the sales of shares, bonds or debentures. Construction MSMEs owners and other customers liquidity, and cash flows such as; commercial banking institutions, mortgage institutions and investment banking. The Commercial bank loans and standby facilities for large projects are typically arranged on a syndicated basis by a group of banks, often referred as consortium of banks. Documents for commercial bank loans arrangement include guarantees and security documents. Non-commercial bank financial institutions, investment banks, finance corporations, are good sources of long-term finance including, the Nigerian industrial development bank (NDB). These sources of financing include: bank overdrafts, term loans and unsecured advances, traditional loan, equipment leasing companies and debt factoring often referred to as external finances (Walker & Hughes, 1984; Onwusonye & Nzotta, 2003).

Development Bank Fund/Multilaterals Institutions:

National and International development bank loans, long-term fixed rate loans at attractive rates may be available for certain construction projects such as sanitary and water facilities etc.

Modern Construction SMEs PF Arrangement:

This is one of the main PF arrangement in recent times, which include all the variants of Public Private Partnership (P3s): Private Finance Initiative (PFIS), Built Operate and Transfer (BOT), Securitization, Unitization, Concessionary (Nesan, 2003; Bao, Peng, Ablanedo-Rosas & Gao, 2015) Real Estate Investment Trust (REITS), Global Financial Market (GFM), Equity Capital (EC), and foreign sources, Foreign Direct Investment (DFI) inflows (Zawawi, Ahmad, Umar, Khamidi & Idrus, 2014; Bao et al., 2015).

Research Method

Sample and Sampling Technique

To determine the appropriate sample size for this study Krejcie & Morgan (1970) table will used:

$$S = \frac{X^2 \mathrm{NP}(1-\mathrm{P})}{d^2(\mathrm{N}-1) + X^2 P(1-P)} \qquad (1)$$

Where; S = required sample size; X^2 = table of value of Chi-square for 1 degree of freedom at the desired confidence level (3.832); N = Population size 2,360 (https://www.vconnect.com); P = Population proportion (assumed to be 0.50), d = degree of accuracy expressed as a proportion (0.05). Substituting for S in eqn. (i) give the sample size population **330**. Researchers recommended that 10% - 20% should be added for none and invalid responses to account for lost questionnaire mails and uncooperative subjects". Therefore, the sample size for this research based on eqn. (i) is **363**.

Sampling Technique

Sampling technique is a process of obtaining information about an entire population by examining only a part of it (Morenikeji, 2006; Haque, 2013). In most research surveys the usual approach is making generalisation or drawing inferences based on samples about the parameters of the population from which the samples are taken. A sample can now be defined as any number of persons, units or objects selected to represent the entire population according to some rule or plan see details table 1, for the composition, number and actual sample size of the construction MSMEs selection in Abuja – FCT.

Purposive sampling technique was employed in order to have an unbiased selection from the list of registered construction MSMEs obtained from CAC and FIRS as respondents operating in Abuja – FCT, given the elements in the population equal chances of being chosen and thirdly, to get a representative number from the population the sample size to be used for the study**.**

Instrument for Data Collection

The instrument with which data will be collected from the target population is a well structure close headed questionnaire with sections A and B. Section A, involves questions regarding the respondent's construction MSMEs features/characteristics. Section B focused on construction MSMEs PF options and the determination of the most important PF options in Nigerian construction industry on a questionnaire for respondents' assessment on a measured on 1-5-point likert type of scale Construction MSMEs perception where: Extent of familiarity; 1 = not familiar, 2 = less familiar, 3 = neutral, 4 = familiar, 5 = very familiarity, level of importance; 1 = unimportant, 2 = important, 3 = moderately important, 4 = highly important 5 = extremely important, and frequency of use; 1 =never, 2 = less often, 3 = neutral, 4 = often, 5 = always.

Table 55: Sample stratum and sample frame

Composition	Number	Actual sample size
Micro	472	73
Small	1180	182
Medium	708	109
Total	2,360	363

Data Analysis

Data obtained from questionnaire survey were collated, sorted, coded and entered into Microsoft Excel MSE, and transform into Statistical Package for Social Sciences (SPSS) version 24 for analysis. Descriptive statistical tools were used; percentage, means scores MS, standard deviation SD, were used to appraise construction PF options and relative important index RII were used to determine the most important PF options by construction MSMEs (Elinwa & Joshua, 2001; Ubani & Ononuju, 2013 Gündüz, Nielsen & Özdemir, 2013; Rooshdi, Majid, Sahamir, & Ismail, 2018). The results obtained were presented using tables.

Mean Score

$$\frac{\sum f(x)}{\sum F} \qquad (2)$$

Where: f = Number of respondents for the attribute rated scale (1, 2, 3, 4 or 5), x = Observed Value or rated scale (1, 2, 3, 4 or 5), f(x) = Product of number of respondents for attribute rated scale and observed value, ∑f(x) = Number of respondents for the attribute rated 3 on scale used, ∑f = Total number of Respondents

Relative Important Index RII

$$RII = \sum W/(A \times N) \qquad (3),$$

where: W = Weightage given to each factor by the respondents, A = Highest weight (i.e., 5 in this case), N = the total number of response questions

Data Presentation, Analysis, And Discussion

Respondent's firms' demographics/Profile

Amongst questions asked, i construction MSMEs including; respondents' category construction MSMEs belong, approximate number of employees in a company payroll, business category construction MSMEs was registered, and years of experience.

Table 2:

Table 2 shows three cases of selected construction MSMEs features/characteristics. The construction MSMEs respondent's; micro, small and medium enterprises have the following frequency and per cent 31, 14%, 92, 42% and 96, 44%. Numbers of employee in a firms' payroll, 1-11employees has a frequency and percentage of 96, 43.80%, 12 – 77 employees have a frequency of 97, 44.30%, while 72-250 employees have a frequency 26, 11.90% respectively. The construction MSMEs years of existence, 16-20yrs has a frequency 75, 34.20%, followed by above 21years with a frequency of 69, 31.50%. This revealed that construction medium MIEs enterprises have the highest frequency and percentage 96, 44%, follow by construction small enterprises SEs with a frequency and percentage 92, 42% and 16-20yrs has the highest frequency 75 and 34% as revealed on table 2.

Table 56: Respondent's Profile/Characteristics

	Profile/Characteristics	Responses	Percent %
1	Category firm belong		
	Micro firm	31	14.20
	Small firm	92	42.00
	Medium firm	96	43.80
	Total	**219**	**100**
2	**Approximate number of employees in your firm**		
	1-11 employees	96	43.80
	12-71employees	97	44.30
	72-250 employees	26	11.90
	Total	219	100
3	**Year of existence of firm**		
	1-5yrs	8	3.7
	6-10yrs	36	16.4
	11-15yrs	31	14.2
	16-20yrs	75	34.2
	above 21yrs	69	31.5
	Total	**219**	**100**

Project financing options available for construction MSMEs in Nigerian construction Industry

Forty-Eight (48) PF options were identify through intensive literature review and were grouped into six (6) main PF options namely; commercial - banking mortgage, Investment banking; traditional sources, non-financial institutions, government financing arrangement, modern financial arrangement and non-interest (Islamic banking) institutions, to manageable size suitable for selection by construction MSMEs with a view to improving construction MSMEs effective participation and performance in Nigerian built environment. Descriptive statistical analysis methods were used such as MS, SD, and RII were used to rank the identified factors under extents of familiarity, level of importance and frequency of use by the construction MSMEs. The best three (3) factors were extracted among from each of the descriptive analysis to form Table 3.

Table 3 shows construction MSMEs extents of familiarity, level of importance and frequency of use of external PF options in Nigerian built environment. The table 3 shows that construction MIEs familiarity with PF options overdrafts was selected and choose first, followed by thrift association saving and loan under traditional sources and PPP under modern arrangement. In addition, under level of importance thrift association saving and loan under traditional sources was ranked and selected first, followed by PPP and Esusu, Adashe. Furthermore, for frequency of use mortgage and overdraft under commercial banking were ranked and selected first and second respectively, followed by PPP. It was revealed that construction MSMEs extents of familiarity, level of importance and frequency of use of PF options; they are familiar, highly important and often use in Nigerian built environment. Secondary, construction SEs extents of familiarity; term loan was ranked first, followed by overdraft and small and medium enterprises loan scheme (SME). Level of importance, appropriation (government budgetary allocation) was ranked first followed by term loans and overdraft.

It revealed that construction SEs are familiar with PF options, the level of importance is highly important, and frequency of use often use. Furthermore, construction MEs use of appropriate PF options using extent of familiarity: overdraft was ranked and choose first, followed by PPP and appropriation (government budgetary allocation). level of importance; appropriation (government budgetary allocation) was ranked and choose first, followed by PPP and appropriation (government budgetary allocation).

Table 57: Construction MSMEs External PF Options using; Extents of Familiarity, level of importance and frequency of use, with (Cronbach's alpha = 0.981 and 0.983) respectively.

		Construction MIEs				Construction SEs				Construction MEs		
S/N	PF Options	MS	STD	RANK	PF Options	MS	STD	RANK	PF Options	MS	STD	RANK
	Extents of Familiarity				**Extents of Familiarity**				**Extents of Familiarity**			
1	Overdrafts	4.23	1.26	1	Term Loans	4.26	1.08	1	Overdrafts	4.48	0.92	1
2	Thrift association (Saving and loan Association)	4.19	1.11	2	Overdrafts	4.26	1.21	2	Public Private Partnership (PPP)	4.44	1.01	2
3	Public Private Partnership (PPP)	4.06	1.39	3	Small and Medium Enterprise (SME) loan Scheme	4.26	1.11	3	Appropriations (government budgetary allocation)	4.44	1.12	3
	Level of Importance				**Level of Importance**				**Level of Importance**			
4	Thrift association (Saving and loan Association)	4.13	1.23	1	Appropriations (government budgetary allocation)	4.14	1.28	1	Appropriations (government budgetary allocation)	4.36	1.10	1
5	Public Private Partnership (PPP)	3.74	1.12	2	Term Loans	4.12	0.91	2	Loans from international financial institutions	4.29	1.15	2
6	Esusu, Adashe and Ajo	3.71	1.19	3	Overdrafts	4.05	1.04	3	Public Private Partnership (PPP)	4.22	1.13	3
	Frequency of Use				**Frequency of Use**				**Frequency of Use**			
7	Mortgage	3.74	1.46	1	Overdrafts	3.90	1.41	1	Mortgage	4.21	1.14	1
8	Overdrafts	3.55	1.67	2	Mortgage	3.89	1.35	2	Public Private Partnership (PPP)	4.15	1.22	2
9	Public Private Partnership (PPP)	3.48	1.59	3	Public Private Partnership (PPP)	3.85	1.53	3	Appropriations (government budgetary allocation)	4.03	1.40	3

Construction MSMEs Views: Familiarity where: 1 = not familiar, 2 = less familiar, 3 = neutral, 4 = familiar, 5 = very familiarity
Level of importance where: 1 = unimportant, 2 = important, 3 = moderately important, 4 = highly important 5 = extremely important
Frequency of usen where: 1 =never, 2 = less often, 3 = neutral, 4 = often, 5 = always
Construction MIEs = Micro enterprises, SEs = Small Enterprises, MEs = Medium Enterprises
Source: Field Survey, 2019

It revealed that construction MEs are familiar, very familiar, with PF options, level of importance highly important and frequency of use often use in the Nigerian built environment.

The most suitable PF options for construction MSMEs in Nigerian built environment

The most suitable PF options for construction MSMEs in Nigerian built environment including;

overdrafts were ranked, and choose first by construction MIEs and MEs, followed by term loan preferred by construction SEs under extents of familiarity. In addition, level of importance of PF options by construction MSMEs in the Nigerian built environment, it was revealed that thrift association (loan and saving association), were ranked and choose first by construction MIEs followed by appropriation (government budgetary allocation) chosen by both construction SEs and MEs respectively. Furthermore, frequency of use of PF options by construction MSMEs, it was revealed that mortgage financing was ranked first by construction MIEs and MEs, followed by overdraft by the construction SEs in Nigerian built environment.

Summary of Findings

From the survey data analysed, table 2 revealed that construction MEs have the highest frequency and percentage use of 96, 44%, followed by construction SEs. Approximate numbers of employees 12-71 has a frequency of 97, 43% and 16 – 12 years of experience has the highest frequency of 74, 34% therefore, this affirmed that the result obtained is adequate for research data analysis (Ankrah, 2009; Pallent, 2011). Conclusively, the study revealed external sources of PF options by construction MSMEs for the purpose of selecting appropriate PF options in Nigerian construction industry, that over draft was ranked and choose first under commercial banking by construction MIEs and MEs followed by term loans by SEs under extents of familiarity with PF options.

Conclusion and Recommendations

Conclusion

The study concludes that reveals, respondent's responses using; extents of familiarity, level of important and frequency of use construction MSMEs uses PF options, shows that external sources of PF options, overdraft, term loans and PPP options with the highest RII, and are the most important option amongst other components to be considered for developing a procedural framework for selecting appropriate PF options by construction MSMEs toward improving their performance in the built environment. The study recommends, that government at all levels should formulate and implement policy at all levels to use a framework to guide construction MSMEs for the selection of appropriate PF options in Nigerian built environment towards improving its performance and organised workshops and training to support its uses.

References

Abdulsaleh, A. M., and Worthington, A. C. (2013). Small and medium-sized enterprises financing: A review of literature. *International Journal of Business and Management*, *8*(14), 36–54. https://doi.org/10.5539/ijbm.v8n14p36

Abor, J., and Quartey, P. (2010). Issues in SME Development in Ghana and South Africa. *Finance and Economics*, (39), 219–228.

Adisa, T. A., Abdulraheem, I., and Mordi, C. (2014). The characteristics and challenges of small businesses in Africa: An exploratory study of Nigerian small business owners. *Economic Insights-Trends and Challenges*, *III(LXVI)*(4), 1–14.

Ali, I. F., Awad, S. H., and Abdulsalam, D. (2019). Critical Factors Limiting the Performance of Small-Scale Construction Firms in Nigeria. *International Journal of Engineering Science Invention (IJESI)*, *8*(08), 46–57.

Ali, M. R. H. R., Mohamad, R., and Bahador, K. M. K. (2018). Developing a Profile of Small-Medium Companies in Leveraging IT for Sustainable Competitiveness. *Journal of Physics: Conference Series*, *1019*(1), 0–9. https://doi.org/10.1088/1742-6596/1019/1/012087

Ankrah, N. A. (2009). *An Investigation into the Impact of Culture on Construction Project Performance*. Wolverhampton.

Arthur-Aidoo, B. M., Aigbavboa, C. O., and Thwala, W. D. (2018). Exploratory factor analysis on drivers of firm's growth among construction SMEs in Ghana. *African Journal of Science, Technology, Innovation and Development*, *10*(1), 20–27. https://doi.org/10.1080/20421338.2017.1380932

Aruwa, S. A. S. (2006). Financing Options for Small and Medium Scale Enterprises in Nigeria. Retrieved April 14, 2009, from https://www.academic.edu

Ayirebi, D., Daniel, O., and Samuel, F. (2017). "Innovation development and adoption in small construction firms in Ghana." *Construction Innovation*, 2017. https://doi.org/org/10.1108/CI-07-2016-0040

Ayodele, A. (2016). Financing Practices of Entrepreneurs in Small and Medium Enterprises in Southwestern Nigeria. *European Journal of Business and Management*, *8*(6), 28–39. Retrieved from www.iiste.org

Baños-Caballero, S., J., G.T., and P., & Martínez-Solano. (2016). Financing of working capital requirement, financial flexibility and SME performance. *Journal of Business Economics and Management*, *17*(6), 1189–1204. https://doi.org/.org/10.3846/16111699.2015.1081272

Bao, H., Peng, Y., Ablanedo-Rosas, J. H., and Gao, H. (2015). An alternative incomplete information bargaining model for identifying the reasonable concession period of a BOT project. *International Journal of Project Management*, *33*(5), 1151–1159. https://doi.org/10.1016/j.ijproman.2014.12.004

Bosede, A., Ogunleye, A., and Arogundade, S. (2016). Analysis of small and medium scale enterprises (SMEs) financing and economic growth: Which way for Nigeria. *European Journal OF Business and Management*, *8*(16), 12–17.

Elinwa, A., and Joshua, M. (2001). Time-Overrun Factors in Nigeria Construction Industry. *Construction Engineering and Management*, *127*(5).

Gambo, N., Said, I., and Ismail, R. (2016). Influences of cost factors affecting technical performance of local government projects in Nigeria: A partial least square-structural equation modeling (PLS-SEM) approach. *Journal of Construction in Developing Countries*, *21*(1), 85–111. https://doi.org/10.21315/jcdc2016.21.1.5

Garcia-Bernabeu, A., Mayor-Vitoria, F., and Mas-Verdu, F. (2015). A MCDM Approach for Project Finance Selection: An Application in the Renewable Energy Sector. *Finance Selection: An Application in the Renewable Energy Sector, Revista Electrónica de Comunicaciones y Trabajos de ASEPUMA*, *16*(2015), 13–26.

Haque, M. (2013). *Sampling Methods in Social Research.* (V. Bharati, Ed.). Santiniketa: West Bangal.

Harrison, R. T., and Baldock, R. (2015). Financing SME growth in the UK: meeting the challenges after the global financial crisis. *Venture Capital*, *17*(1–2), 1–6. https://doi.org/10.1080/13691066.2015.1050241

Hassanein, A. G., and Adly, S. W. (2008). Issues Facing Small Egyptian Construction Firms: The Financing Barrier. *Journal of Small Business & Entrepreneurship*, *21*(3), 363–376.

Kenley, R. (2003). *Financing Construction Cash Flow and Cash Farming*. New Zealand.: UNITEC.

Krejcie, R. V., and Morgan, D. W. (1970). Determining sample size for research activities. *Educational and Psychological MeasurementPsychological Measurement*, *30*, 607–610.

Kumar, S., and Rao, P. (2016). Financing patterns of SMEs in India during 2006 to 2013–an empirical analysis. *Journal of Small Business and Entrepreneurship*, 1–35. https://doi.org/.org/10.1080/08276331.2015.1132513

Kuruppu, G., and Azeez, A. A. (2016). Financing preferences of small and medium enterprise owners of Sri Lanka: Does pecking order theory hold ? *Journal of Business & Economic Policy*, *3*, 79–92.

Morenikeji, W. (2006). *Research and Analytical Methods (For Social Scientists, Planners and Environmentalist)*. (U. P. Limited, Ed.) (First). Jos: Jos University Press Limited.

NBS, and SMEDAN. (2012). *A survey report on Micro, Small & Medium Enterprises in Nigeria (NSME): Preliminary report 2010 national MSME collaborative survey*. *Preliminary report*. Abuja.

Nesan, J. L. (2003). Project Finance Model for Small Contractors in USA. *AJCB*, *16*(1).

Nevitt, K. P., and Fabozzi, F. (1998). *Project Financing* (8th ed.). USA: Euromoney Publication.

Nwachukwu, C., and Emoh, F. (2011). Building construction project management success as a critical issue in real estate development and investment. *American Journal of Social and Management Sciences*, *2*(1), 56–75. https://doi.org/10.5251/ajsms.2011.2.1.56.75

Nwanyanwu, A. L. (2014). Cost of Loan Capital and Capital Asset Acquisition in Nigeria: Implications on Organisational Profitability. *Journal of Business and Management*, *6*(26), 199–208.

Ojha, S., and Pandey, I. M. (2017). Management and financing of e-Government projects in India: Does financing strategy add value? *IIMB Management Review*, *29*, 90–108. https://doi.org/10.1016/j.iimb.2017.04.002

Onwusonye, S. I. J., and Nzotta, S. M. (2003). Project financing: A panacea for efficient procurement and delivery of turnkey projects. *NIQS*, *45*(04), 24–28.

Osmond, O., and Paul, O. (2016). Small and Medium Scale Enterprises Financing In Nigeria: Problems and Prospects. *International Journal of Innovative Social Sciences & Humanities Research*, *4*(1), 77–86.

Pallent, J. (2011). *SPSS Survival Manual A Step-by-Step quide to data analysis using SPSS* (4th ed.). Crows Nest: Allen & Unwin.

Tang, C. M., Wong, C. W. Y., Leung, A. Y. T., and Lam, K. C. (2006). Selection of funding schemes by a borrowing decision model: A Hong Kong case study. *Construction Management and Economics*, *24*(4), 349–365. https://doi.org/10.1080/01446190500434906

Ubani, E., and Ononuju, C. N. (2013). A study of failure and abandonment of public sector- driven civil engineering projects in Nigeria: An empirical review. *American Journal of Scientific and Industrial Research*, 74–82. https://doi.org/10.5251/ajsir.2013.4.1.75.82

Walker, A., and Hughes, W. (1984). Private industrial project management: a systems-based case study. *Construction Management and Economics*, *2*(2), 93–110. https://doi.org/10.3109/10903127.2011.616260

Wang, J. L. (2017). Research on Financing and Decision from Micro Enterprises in China. *Open Journal of Business and Management*, *5*, 372–387. https://doi.org/org/10.4236/ojbm.2017.52032

Yan, X., Chong, H.Y., Sheng, Z., and Wang, X. (2017). Financing decision model for toll roads: Balancing economic and public attributes. *Journal of Management in Engineering*, 04017010–04017013. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000523

Zawawi, N. A. W. A., Ahmad, M., Umar, A. A., Khamidi, M. F., and Idrus, A. (2014). Financing PF2 projects: Opportunities for islamic project finance. *Procedia Engineering*, *77*, 179–187. https://doi.org/10.1016/j.proeng.2014.07.015

Impact of Post-COVID Era on Contractors' Managerial Capability towards Performance of Construction Projects in Abuja, Nigeria

Zubair, A.
Department of Quantity Surveying, The Federal Polytechnic Idah, Nigeria
zubairahmed6295@gmail.com

Abstract:

This study examined the impact of post-COVID era on the work and performance of contractors handling construction projects in Abuja. The study deployed qualitative research methods leading to the successful interview of 22 out of 40 contractors that were drawn using convenience sampling techniques. With recourse to descriptive statistics and frequency distribution tables, the two major challenges confronting the performance of contractors in the study area were found to include operational- and financial challenges comprising increased price of materials, labour and material shortage, and project delays. Among the recommendations put forward to address these challenges include market survey and bulk purchase, review of project budget, and government intervention through the provision of financial incentives. It was drawn from the study that the contractors should be wary of the significant impact that environmental-, economic-, and governmental policies arising from global health challenges could exert on their managerial performance even in the post-COVID era.

Keywords: COVID–19, managerial capability, contractors' performance, post-COVID era, construction projects.

Introduction

The construction industry has been among the industrial sectors mostly affected by the Coronavirus diseases (COVID-19) pandemic, therefore, efforts, are geared towards managing the impact and piloting projects through this post-COVID period. The construction sector, have been affected in a number of ways. Since the pandemic began, there have been fewer employment opportunities partially due to work disruptions and shortage of personal protective equipment (Rouhanizadeh et al., 2019). As a result, the global economy deteriorated to its worst level in decades and the construction sector in Russia, America, Europe and other countries suffered various consequences such as suspending and cancelling activities, lack of suppliers' ability to deliver essential construction materials, uncertainty regarding future projects, workforce problems, increased costs, in addition to a set of legal issues (Husien et al., 2021). During the past year, various researchers have discussed the effects of COVID -19 on the construction industry. Yadeta and Pandey (2020) emphasized that the COVID-19 pandemic has left an enormous amount of uncertainty regarding contractual implications for those involved in the construction industry. Permesly et al. (2021) revealed that the impacts on construction projects includes, delays as-built schedule, changes in productivity, escalating labour and material costs, increased overhead, the time for project completion and each party bearing its own costs during force majeure event.

In Nigeria Kabiru and Yahaya (2020) concluded that COVID-19 harmed the construction industry as it has obstructed site work, affected the bill of quantities, project completion and the law of contract. Osuizugbo (2020) attributed project abandonment, delay in construction activities, and high cost of construction materials and shortage of workforce among the disruptions in the Nigeria construction sector. Yusuf et al (2021) observed that the COVID-19 pandemic has led significantly to project cost overrun, project time overrun and litigation arising from construction disputes, for this reason, Yadeta and Pandey (2020) identified collaboration and good communication between government and contractors to be an essential solution. Ozili (2020) suggested adequate social welfare packages to swiftly cushion the effect of the pandemic. Similarly, Husien et al. (2021) suggested safe work site conditions, creative and innovative solutions and fair legislation as possible measures to address these challenges. According to Baniya et al.(2021), the pandemic has challenged the developing world to meet sustainable development goals (SDGs) affecting construction.

Ebekozien et al., (2021) reiterated that the COVID-19 pandemic unleashed a negative impact on the achievement of sustainable development goals (SDGs) from the dimension of construction projects and the contribution of the construction sector. In addition, It is expected that the performance of projects is correlated with the managerial capacity of these contractors'. For instance, the responsibility to pay instalments of loan and interest, office rent, staff salaries, and taxes, among other obligations and burdens might likely affect the mental health of contractors. It is against this background that this study is aimed at assessing the impact of post COVID-19 by contractors on their work performance of construction projects in Abuja. To achieve this aim the objectives are as follows:

(a) To identify the challenges faced by contractors during COVID-19 on their work progress,

(b) To establish possible measures to address the challenges faced by the contractors'; and

(c) To determine the implication of COVID-19 towards contractors' performance.

Review of Literature

Impact of COVID-19 pandemic on the global construction projects

Back in December 2019, the world experienced the first case of COVID-19 from Wuhan city, China, and with a trajectory of rapid spread across the globe to become a global pandemic as at March 2020 (World Health Organization, 2020).

A number of studies have examined the impact of COVID-19 on construction projects. Alsharef *et al.* (2021) found some of the impacts of COVID-19 on construction sectors in the USA to include material delivery delays and shortage, delays in inspections and securing permits, reduction in efficiency and production rate, showing of ongoing projects and delay in the start of new projects, price escalations, additional costs, loss of revenue, payment delays, safety concerns, workforce shortages, and expected increase in disputes, litigation and claims. Zamani et al. (2021) on their part identified the adverse impact of the COVID-19 pandemic to include shortening of timeline of construction activities, late approvals by related authorities, shortage of skilled workers, and delayed supplies and logistics.

Amri (2021) examine the economic impact of COVID-19 on the construction industry in Oman. According to Amri (2021), the falling oil prices and disruption in supply chain have further increases the financial burden of Oman's construction industry. Similarly, Umar (2021) observed some of the critical impact of COVID-19 to the construction projects to include delays of the construction projects as well as the challenge of effectively managing a workforce that cannot adapt to the "work from the home" style of services delivery, coupled with the health and safety issues posed by the COVID-19 pandemic era.

Thapa and Shrestha (2021) on their own part identified the impacts of the COVID-19 pandemic to include disruption in the supply chain of materials arising from a halt in maritime transport and aviation industries. Among the implications include increase in project cost and time arising from uncertainties in international trade and supplies as well as restrictions in movement imposed by governments. Gamil and Alhagar (2020) in their study identified the impacts of the COVID-19 pandemic on construction to include suspension of projects, labour impact and job loss, time overrun and financial impact. Contractors were confronted with legal issues due to the nonconformity of contractual terms, which is caused by the suspension of the projects and sudden fluctuation of material price. Neupane and Mishra (2020) found that homeowners exercised less trust for native labourers to the extent of engaging migrant skilled workforce that subsequently became difficult to retain due to foreign exchange crunch associated with the COVID-19 pandemic and the systematic lockdown of economic activities. In other words, it became extremely difficult for contractors to engaged labourers on site, including personnel for the operation of heavy duty machineries. Yadeta and Pandey (2020) on their own part found that the COVID-19 pandemic had provoked uncertainties in the construction industry and all stakeholders involved in project delivery to the extent that most parties had to rely on the clause of *force majeure* to instantiate the re-negotiation of some contract terms.

In a review of the implications of the COVID-19 pandemic in Malaysia, Timilsina et al. (2021) identified how delays in construction projects was triggered by the shortening of daily working hours. Kabiru and Yahaya (2020) concluded that COVID-19 harmed the construction in Nigeria through the obstruction of work on site. Other adverse impacts identified by Kabiru and Yahaya (2020) include invalidation of bills of quantities, delayed project completion, and review of construction contracts. However, Ogunnusi *et al.* (2020) noted that construction companies adopting and implementing technology were able to reap the rewards of their investment during the COVID-19 era as they had the leverage for better collaboration, increased productivity, and project completion within the time and budget threshold.

Impact of COVID-19 on construction projects in Nigeria

The contribution of construction activities and the significant role it plays to the nation's economic, environmental and social development cannot be over emphasized (Isang, 2016). The industry represents 13% of global GDP, with its output worth more than $100bn a year, providing employment for millions of people (Dania et al., 2013). These benefits were however shortlived following the COVID-19 pandemic. According to Yusuf et al (2021), the construction industry like other economic sectors was not spared of the adverse effects of the pandemic. Osuizugbo (2020) revealed how the pandemic posed problems for the transportation of both materials and personnel, cost of construction materials, reduction in working hours per day, funding and shortage of workforce, and project completion. Yusuf *et al* (2021) found that the COVID-19 pandemic has led significantly to project cost overrun, project time overrun, and litigation arising from construction disputes. Finally, Ebekozien *et al* (2021) suggested that the fourth Industrial Revolution (4IR) technologies can stir up attaining SDGs-associated with the construction sector in the post COVID-19 recovery era. A summary of studies addressing this impact have been captured in Table 1(a).

At this juncture, it is expedient to study the impact of post COVID-19 era on contractors' managerial capability towards performance of construction projects in the study area.

Table 1a: A Tabulation of Literature on the Impact of COVID-19 on the Construction Sector

Key impacts.	Source
Community instability unemployment	Baniya *et al.* (2021)
Material delays and shortage; and efficiency	AIsharaf *et al.* (2021), Umar (2021)
Production rate reduction; additional costs; loss of Revenue, project cost overrun, project time overrun.	Ogunnusi *et al.* (2020), Gamil and AIhagar (2020), and Yusuf *et al*. (2021).
Project abandonment; delays; high cost of construction materials; shortage of workforce.	Osuizugbo (2020)

Table 1b: A tabulation of literature on the key challenges posed by COVID-19

Key challenges	Source
Health and safety risk; heavy workloads.	Bailey *et al* (2020), Pamidimukkala & Kermanshachi (2021)
Legal issues, and project suspension.	Gamil & AIhagar (2020)
Effects on bill of quantities and law of contracts.	Kabiru & Yahaya (2020)
Operational, economics and financial matters.	Zamani *et al*. (2021), Amri (2021)
Supply chain disruptions, fluctuation in material prices, delay working period shortened.	Thapa & Shrestha (2021), Permesly (2021)
Sustainable development goals (SDGs)	Ebekozien (2021)

Table 1c: ***A tabulation of literature on Resilience measures for COVID-19***

Key measures	Source
Working weekends	Salami et al. (2021)
Social distancing, provision of sanitizers and washing.	Pamidimukkala and Kermanshachi (2021), Osuizugbo (2020)
Station, temperature checks; use of personal protective equipment.	Permesly et al. (2021)
Safe work site condition, creative and innovative solution, cooperative and fair legislation.	Husien et al. (2021)
Remote working.	Ogunnusi et al. (2020)
Collaboration and good communication between government and contractors.	Yadeta and Pandey (2020)
Adequate social welfare packages.	Ozili (2020)

Contractors' managerial capacity

Contractors' involvement in construction projects demand that they should be able to exercise modern managerial skills in addition to their traditional bias in the design and construction process. The heightened competition in the construction industry requires good managerial skills and improved productivity (Hendrickson and Au, 2000). According to Aje (2008), managerial capability (capacity) implies quality control program and quality of work on past project. This encompasses construction planning, programming and general progress, site organization, coordination of engineering works, and capability of key site personnel. An exhibition of good construction management skills by contractors is a product of training as against natural endowment. This accounts for why educational qualification and skills of contractors constitute vital considerations for contractor pre-qualification. In addition to correlation with the experience of technical personnel and management acumen of the contractor and his team, the management capability of a contractor is correlated with the past performance and quality of work executed (Hatush, and Skitmore, 1997, Cheung, Sueng and Cheung, 2004, Aje, 2008, Huang, 2011).

The implications on contractors' performance

According to Araujo et al (2016), evaluating the performance of the contractors is crucial because the success of a project depends on it. It was found in the study carried out by Meng and Fenn (2019) that indicators used to measure contractor's performance on a construction project revolve around time performance, cost performance, quality performance, client's satisfaction and team satisfaction.

Work performance challenges confronting contractors

In an array of surveys conducted during the COVID-19 era, the factors found to have exerted negative impact on project performance and triggered delayed project completion include suspension of works due to government order, economic factors, safety, and health concern (Bailey et al., 2020, Gamil and AIhagar, 2020; Kabiru and Yahaya, 2020; Pamidimukkala and Kermanshachi, 2021). Other identified challenges include lack of a safe environment in the workplace, heavy workloads, home situations and concerns about job stability are contributing factors that management encounter with their construction workers (Bailey et al., 2020). On the contractual side, Gamil and AIhagar (2020) noted that contractors in Malaysia are inevitably faced with legal issues due to the nonconformity of contractual terms which is caused by the suspension of the project and sudden fluctuation of material prices.

Measures for addressing the impact of covid-19 on project performance

The emergence of the COVID-19 pandemic has triggered the resilience of various sectors of human endeavour to evolve strategies aimed at mitigating the adverse impact on the conventional ways of doing things. Consequently, the construction industry has been able to evolve a number of measures aimed at mitigating the adverse impacts of the COVID-19 pandemic, and with the possibility of reviewing these measures even in the Post-COVID era. For instance, Simpeh and Amoah (2021) identified three measures for the curtailing of COVID-19 spread among construction site workers to include screening, restriction of site access, and proper handling of material and equipment delivery and use on site in accordance with the COVID-19 safety protocols. Furthermore, Salami et al (2021) stated that companies have devised some means like working weekends only when the site is usually empty, while others have used strategies like working from the home. Pamidimmukkala and Kermanshachi (2021) demonstrated that redefining workforce site safety by placing signs, ensuring a safe distance between workers, providing sanitizers and washing stations in the fields, and also using effective technologies would help to curb COVID-19 spread and enhance project productivity. In addition, Osuizugbo (2020) and Permesly et al (2021) agreed that installing hand sanitizing stations, the use of safety signs and posters, imposing face masks wearing among labourers; thermal screening of personnel and access controls to the site.

Although the study credited to Ogunnusi et al (2020) was tailored towards a global audience as against the Nigerian context. Yusuf et al (2020) in their study focused on COVID-19 pandemic in the Nigerian context as it pertains to digitalization of operations and processes in the construction industry, whereas, Osuizugbo (2020) focused on disruptions and other challenges arising from the COVID-19 pandemic and the agility of the Nigeria construction industry. Notwithstanding, this study intends to address the COVID-19 resilience gap through an inquiry into measures deployed by contractors to boost their performance on construction projects especially in the post-COVID recovery era, taking into consideration the environmental, social and economic challenges encountered by these contractors.

RESEARCH METHODOLOGY

This study adopted the qualitative approach, entailing the use of a semi-structured interview with a framework of various themes to be explored. The qualitative approach was used to gain deeper insight into the research problem, through a series of interaction with contractors and their experience of project execution during the COVID-19 pandemic as well as measures that they employed to achieve sustainable project performance so that lessons could be drawn for the post-COVID era.

Data for the study were harnessed from 40 interviewees intially drawn using the convenience sampling technique. The 40 interviewees were selected in Abuja, Nigeria's Federal Capital Territory based on their knowledge and expertise in executing construction projects. From a convenience sample of 40 respondents, only 22 respondents were able to provide the required information for the study.

The in-depth interviews were conducted with stakeholders in the construction sector in Nigeria comprising of Contractors, Consultants, and Clients in Abuja between the period of September and October 2022. The respondents were selected due to their experience in construction business and have direct involvement in on-going construction projects.

The semi-structured interview commenced with questions eliciting background data of the interviewees, analyses of which were carried out using descriptive statistical tools comprising frequency distribution tables and simple percentile. Thereafter, three major questions were asked based on the research objectives:

1. What challenges did you encounter on construction projects as a result of COVID-19 pandemic?
2. What were the implications towards performance of construction projects?
3. What post-COVID measures have you employed to address these challenges to achieve project performance?

The study used thematic analysis to examine the responses provided by participants' in the course of data collection. In using thematic analysis, themes and sub-themes were generated (Braun and Clarke, 2006). As explained by Shank (2006) an inductive analysis of participants' experiences in the qualitative perspective was used. Themes and sub-theme were thereafter generated by searching, reviewing and defining the coded thematic text. The extracted data was finally analyzed and the findings were reported using texts.

RESULTS AND DISCUSSION

Background information about the interviewees

Table: 2 indicates the background information about the respondents in term of their profession, academic qualification of respondents, membership of professional bodies, cadre of professional bodies, type of organization/firm and years of experience. A cursory examination of the table indicates that 9.09% of the respondents hold Msc/MTech/MEng degrees, 13.64% hold a postgraduate diploma, 45.45% hold first degrees, while 31.82% hold a Higher National Diploma. This result implies that majority of the respondents obtained higher qualifications. The professional bodies of respondents were NIA, 22.73% NIQS, 22.73% and NSE 22.73%.

The result implies that respondents have adequate working experience in the built environment. The types of Organization/Firm of respondents were consulting, 18.18% client 9.09% and contracting, 72.73%. This implies that the stakeholders in the built environment were the respondents in the study where contractors representing the major figure head on construction projects. The average year of experience is 29.14 which imply that respondents have acquired adequate knowledge and expertise in executing construction projects.

Table 2: Background information about respondents

Category	Classification	Frequency	Percentage
Academic qualification of respondents	MSc/MTech/MEng	2	9.09
	PGD	3	13.64
	BSc/BTech/BEng	10	45.45
	HND	7	31.82
	Total	22	100.0
Membership of professional bodies	NIA	5	22.73
	NIOB	4	18.18
	PMIN	3	13.64
	NIQS	5	22.73
	NSE	5	22.73
	Total	22	100.0
Cadre of professional membership	Member	17	77.27
	Associate	3	13.64
	Graduate/Probationer	2	9.09
	Total	22	100.0
Type of organization/firm	Contracting	16	72.73
	Consulting	4	18.18
	Client	2	9.09
	Total	22	100.0
Years of experience in construction Business	1 – 10	1	4.54
	11 – 20	3	13.64
	21 – 30	5	22.73
	31 – 40	13	59.09
	Total	22	100.0
	Mean = 29.14 years		

Challenges of project construction arising from the COVID-19 pandemic

In pursuit of the first objective of this study, the interviewees were asked to state the challenges that they had encountered in the implementation of construction projects during the COVID-19 era. Their responses were thematically categorized into operational and financial themes. Coming under the ambit of the operational theme are six challenges, whereas three challenges were found to be associated with the financial theme as indicated in Figure 1.

The operational challenges of construction project execution in the COVID-19 era

Certain operational such as shortage in labour supply, inadequate supply of materials, health and safety issues, project delay and low patronage and management difficulties were encountered. Other challenges encountered in construction projects as a result of COVID-19 were attributed to inflation in the Nigerian economy which escalated the price of building material, notably cement from N2,700 naira to N4,500 naira per bag. This contributed to price increment and resource scarcity experienced by contractors concerns over health and safety, labour issues such as relocation or withdrawal of personnel were also operational related challenges. This result echoes the assertion of Gamil and Alhager (2020) that projects-in-progress might likely face challenges such as shortage of workers, the risk of materials price and shortage of material and supply chains.

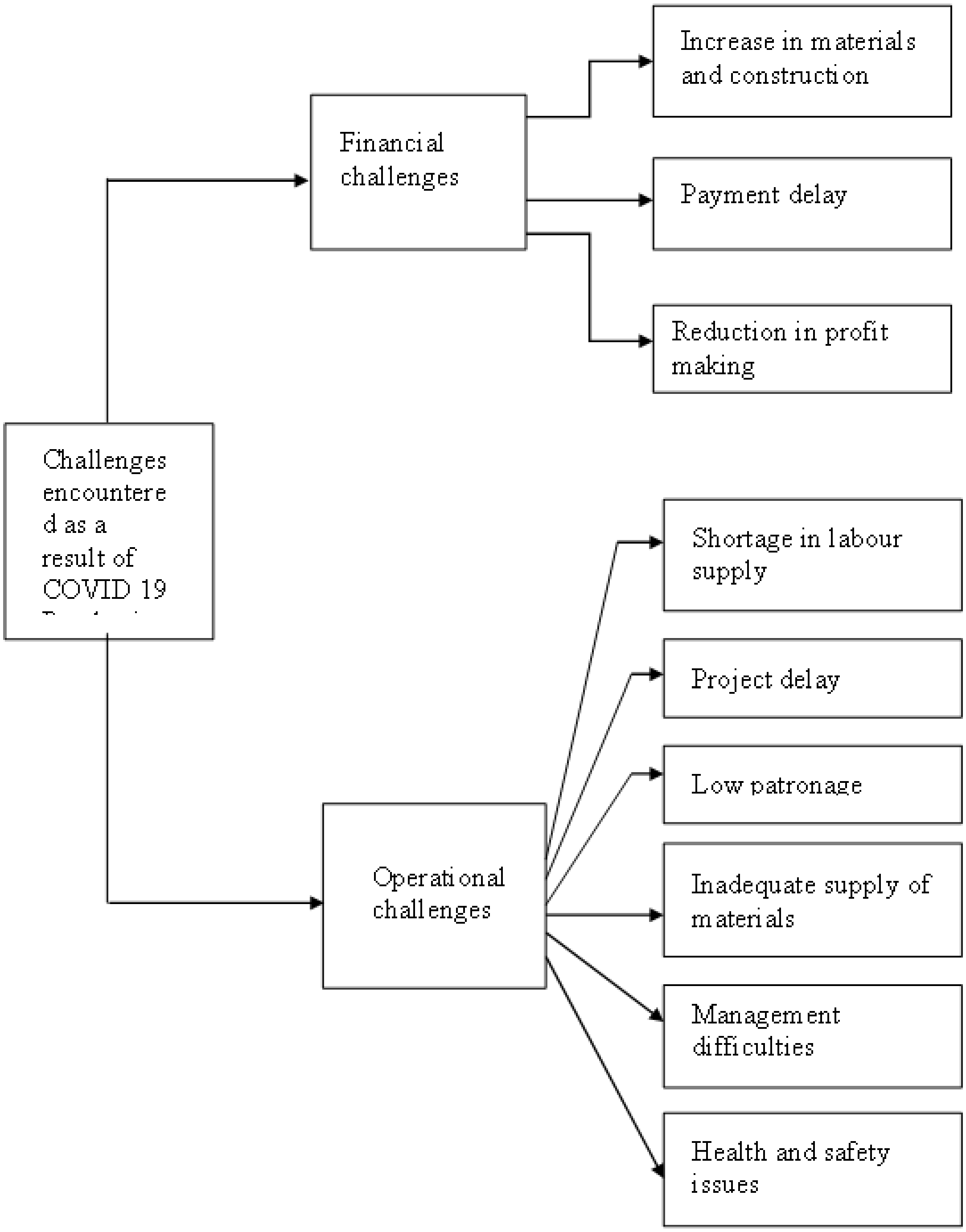


Figure 1: Specific challenges encountered by contractors in Nigeria as a result of COVID-19 pandemic

More insights drawn from the findings revealed that, the inability of contractors to move freely due to restriction in movement reduced the efficiency of the workers on the worksite, making labour and material supply along with project supervision difficult.

This result agrees with previous work by Alsharef et al (2021) that COVID-19 impacted material delivery delays, workforce shortages, reduction in efficiency and production rate, slowing on-going and new projects. Another finding from the study shows that the issues of low patronage, difficulties in recruiting skilled and unskilled labour, low workforce due to reduction and withdrawal of construction workers are social sustainability themes established in this study. This finding lends Kermanshachi (2021) that labour impact, concerns about job stability and job loss are factors caused by COVID-19.

The study shows that training construction workers on being health and safety conscious, provision of hand sanitizers and nose mask are among the health and safety measures employed in construction projects. This shows that contractors promoted continuous health and safety improvement and adherence to COVID-19 protocols at construction sites. This finding is in agreement with previous studies by Permesly et al. (2021) that safe work site conditions, provision for hand washing and sanitizers, and the use of face masks are measures to address COVID-19 challenges, which can be deduced as an environmental aspect of construction safety.

Financial challenges of construction project execution in the COVID-19 era

As indicated in Figure 1, financial difficulty appears to be a major economic challenge experienced as a result of the pandemic. Findings from the study indicate that contractors experienced little or no profit. Delayed payments further affected the contractor's cash flow in the project. Also, the study reveals that increase in the cost of human and material resources on the site along with increase in construction cost were challenges experienced by contractors. This finding is consistent with Osuizugbo (2020) and Yusuf et al. (2021) that high cost of construction materials and additional cost are among the effects of COVID-19 in the Nigerian construction sector

Also found in connection with this study is possibility of contractors using cost monitoring strategies through market survey and bulk purchase to address the increase in material cost. This measure assists in improving project cost overrun in contractor's quest for project performance in the post-COVID era. Also, management measure in exploring remote working technologies such as Microsoft office and Zoom video conferencing have been revealed as a measure to achieve project performance in a non-COVID world. This finding conforms to the observation of Ogunnusi et al. (2020) that, construction companies that are adopting and implementing technology, especially in this COVID-19, will have better collaboration and increased productivity. This shows the benefits to be derived following the import of technological innovation in construction project delivery in Nigeria.

Measures to mitigate challenges faced by contractors in the post-COVID-19 era

On the basis of the interviews granted in the course of the study, measures aimed at addressing the challenges confronting contractors in the course of implementing construction projects in the post-COVID-19 era were indentified. The challenges were structured under three thematic areas namely Managerial, contractual and governmental challenges, from where a total of fourteen intervention areas were derived as indicated in Figure 2.

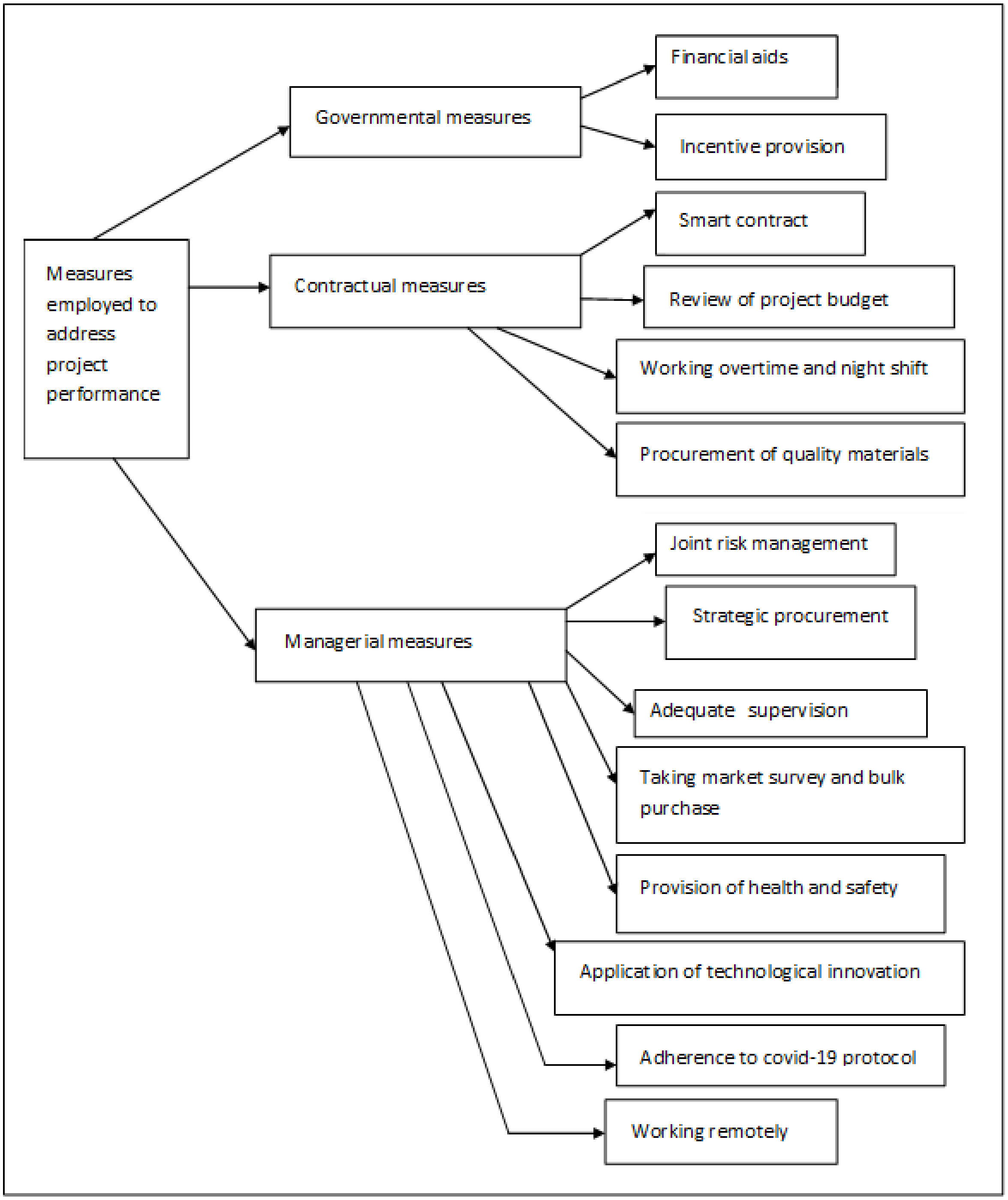


Figure 2: Measures Deployable by contractors to mitigate adverse impact of COVID-19 on

Managerial measures employed for project performance

In order to surmount the managerial challenges posed by the COVID-19 pandemic, measures to be put in place include promotion of health and safety, taking market survey and bulky purchase, adequate supervision, working remotely, application of technological innovation, strategic procurement, joint risk management and adherence to COVID-19 protocol. While talking about promotion of health and safety, a contracting Quantity Surveyor interviewed articulated that they created safety consciousness in their workers and ensured adherence to safety protocols such as cleanliness. In order to address the increase in the price of building materials, the Contractors undertook market survey to ascertain the current price of materials needed before carrying out their quotations and the actual purchase. The management measure of exploring remote working technologies such as Microsoft office and Zoom video conferencing have been revealed to enhance project performance prior to the COVID era. However, its deployment is the COVID and post-COVID era could be beneficial to innovation and project performance in Nigeria.

Contractual measures employed for project performance

In order to ensure project performance, the contractors were found to have employed certain measures such as reviewing of project budget, overtime and night shift, procurement of quality materials and smart contract. A Quantity Surveyor interviewed revealed that, as a result of the pandemic, the price hike compelled them to review the budget of their construction projects. He added that they revisited the budget of projects they had prior to COVID-19 and reviewed it upwards to accommodate the current market price and their workers' remunerations. Construction Manager declared that he employs smart contract strategy to ensure project performance in the post-COVID-19 era.

The four sub-themes under contractual measures for the mitigation of the adverse impact of COVID-19 include review of project budget, smart contract, working overtime and night shift and procurement of quality materials. Hence, a complete change in procurement operations, the use of fluctuating fees contract, integrated design practice, joint risk management and reviewing contract rates to accommodate price increase are contractual measures contractors are employing to address post-COVID challenges, which are in tandem with the work of Yadeta and Pandey (2020) regarding the re-negotiation and amendments of contract terms.

Government measures employed for project performance

Financial aids and provision of incentives were among the two key governmental strategies the interviewed noted would ensure project performance. As narrated by the interviewee, relief funds should be provided to the contractors by the government to relief them of the resulting financial burden of the pandemic. Quantity Surveyor further articulated that the government should give them the opportunity to access grants and loans, so as to keep their operation running in the worksite, pay their workers' salaries and support the project cost. Further to this, other interviewees noted that incentives should be provided to the workers on site to motivate them and ease the burden of the pandemic.

Coming under the governmental measures in Figure 2 are sub-themes comprising governmental relief funds and loan, provision of incentives for worker. The role of the government in providing relief funds and loans can go a long way in sustaining contractors during the post-COVID period. Therefore, findings from this study support the call for the provision of financial aid by the government and clients in the form of relief funds and loans. This can take the form of introducing incentive and overtime for workers to assist contractors in operation, paying staff salaries and supporting the project cost. This is in agreement with the studies credited to Osuizugbo (2020) and Ozili (2020) that adequate funding and social welfare packages can swiftly cushion the effect of the pandemic in Nigeria, this implies that for construction sector to survive in construction business in the post-COVID era all these economic aspect must be fully utilized for sustainability of project performance.

Conclusion and Recommendations

This study examined the challenges faced by contractors on their work performance during COVID-19 and proffers possible measures to address challenges faced by contractors towards performance in the post-COVID era. Iy was found that contractors have encountered operational and financial challenges during the COVID-19 era. It was further observed that construction projects in Abuja, the study area were affected by increase in the prices of materials, health and safety issues, shortage of labour and material supply, reduced profit and delays in project. The challenges confronting constractors in the study area were conceptualized as requiring three intervention measures namely managerial-, contractual- and governmental measures. At management level, more attention has been drawn to safeguarding the health and safety of construction workers in a post-COVID era. Despite the initial challenge of managing project remotely, contractors in Nigeria are applying innovative technologies like Video calls for better productivity. From the financial perspective is the need to adopt cost control measures such as market surveys, feasibility studies, and cost monitoring. whereas the government could help in providing the enabling economic environment through subsidies, regulation of cost of borrowing and servicing construction loans among other incentives aimed at assisting contractors to cover cost of project execution including capital costs, recurrent expenditure, and overheads. It is recommended that contractors factor into worker's remuneration the impacts of overtime work and shifts aimed at providing extra compensation for time and resources put in by the workforce in the post-COVID era. Finally, it is recommended that global pandemics like the COVID-19 should be treated in construction contracts as a force majeure events given the painful experience and footprints it had left in the sands of time, as it did not spare any aspect of human endeavour including the construction sector.

References

Alsharef A., Banerjee, S., Uddin, S.M.J., Albert, A. and Jaselskis, E. (2021). Early impacts of the COVID-19 pandemic on the United State construction industry. *International Journal of Environmental Research and Public Health*, 18, Article No. 1559.https://doi.org/10.3390/ijerph18041559.

Aje. O. I. (2008). The impact of contractors' Prequalification and Criteria of award on construction project performance in Lagos and Abuja, Nigeria. Unpublished PhD thesis, the School of Postgraduate Studies, Federal University of Technology, Akure.

Amri, T. A. (2021). The Economic Impact of COVID-19 on construction Industry: Oman's Case *European Journal of Business and Management Research.* 6, 146-152 https://doi.org/10.24018/ejbmr.2021.6.2.806

Araujo, M. C., Alencar, L. H., & Mota, C. M (2016). Model for contractor performance evaluation in construction industry. 2016 IEEE International Conference on systems, Man, and Cybernetics (SMC), 2631-2635. https://doi.org/10.1109/smc.2016.7844636.

Bailey, J., Bouchardie, N. and Madalena, I. (2020). COVID-19: *the current impact on construction and Engineering Projects,* White & Case LLP, available at: https://www.whitecase.com/insight-alert/covid-19-current-impact-construction-and-engineering-projects.

Baniya, B., Ghimire, A. and Mahat, A. (2021). Impact of COVID-19 on the world economy and sustainable development goal in Nepal. COGNITION *A Peer-Reviewed Tran disciplinary Research Journal,* Vol. 3, pp. 27-35.

Braun, V., & Clarke, V. (2006). Using Thematic Analysis in Psychology. *Qualitative Research in Psychology,* 3, 77-101.https://doi.org/10.1191/1478088706qp0630a.

Cheung, S.O., Sueng, H.C.H, and Cheung, K.K.W (2004). PPMS: A Web-based Construction Project Performance Monitoring System *Automation in Construction,* 13, 361-376.

Ebekozien, A., Clinton Aigbavboa, C. and Aigbedion, M. (2021). Construction industry post-COVID-19 recovery: stakeholders' perspective on achieving sustainable development goals. *International Journal of Construction Management,* available at: https://www.tandfonline.com/doi/full/10.1080/156235992021.1973184

Gamil, Y., & Alhagar, A. (2020). The impact of the Pandemic Crisis on the Survival of Construction Industry: A Case of COVID-19. *Mediterranean Journal of Social Sciences*, 11, 122-128. https://doi.org/10.36941/mjss-2020-0047

Hatush, Z., and Skitmore, M.(1997).Criteria for contractor selection. *Construction Management and Economic*, 15.19-38.

Hendrickson, C. and Au, T. (2000). *Project Management for Construction: Fundamental Concepts for Owners, Engineers, Architects and Builders.* (2nd Ed). UK: Prentice Hall Retrieved June 24, 2006 from https://www.ce.cmu.edu/pm book/01_The Owners'_Perspective.html.

Husien, I.A., Borisovich, Z., and Naji, A.A. (2021). COVID-19: key global impacts on the construction industry and proposed coping strategies. doi: 10.1051/e3sconf/202126305056.

Huang, X. (2011). An Analysis of the Selection of project Contractor in the Construction Management Process. *International Journal of Business and Management*, 6 (3), 184-189.

Isang, I.W. (2016). Appraisal of the implementation of sustainability practices during construction phase of building projects in Akwa Ibom state, M.Sc. Dissertation, University of Uyo, Nigeria.

Kabiru, J.M. and Yahaya, B.H. (2020). Can covid-19 consider a force majeure event in the Nigerian construction industry? *International Journal of Scientific Engineering and Science*, 4, 34-39.

Meng, K., & Fenn, P. (2019). Performance measurement for construction projects. In Project Management Development – Practice and Perspectives (8th *International Scientific Conference on Project Management in the Baltic Countries ed.*, pp89-203). Riga, Latvia: University of Latvia.

Neupane, B. R. & Mishra, A. K. (2020). Impact of COVID-19 on Labour Management: A Case of Reconstruction Works at Bharatpur Metropolitan City, Nepal. East African *Scholars Journal of Economics, Business and Management*, 3, 789-794.https://doi.org/10.36349/easjebm.2020.vo3110.004

Ogunnusi, M., Hamma-adama, M., Salman, H. and Koulder, T. (2020). COVID-19 pandemic: the effects and prospects in the construction industry. *International Journal of Real Estate Studies*, Vol.14 No.2, pp. 120-128, available at :https://www.utm.my/intrest/files/2020/11/2_MS_CRES-Covid-025.pdf.

Osuizugbo, I.C. (2020). Disruptions and responses within Nigeria construction industry amid COVID-19 threat. *Covenant Journal in Research and Built Environment*, 8(2), 37-48, available at: http://journals.covenantuniversity.edu.ng/index.php/cjrbe

Ozili, P.K. (2020). COVID-19 pandemic and economic crisis: the Nigerian experience and structural causes. *Journal of Economic and Administrative Sciences*, 1-30, doi: 10.1108/JEAS-05-2020-0074.

Pmidimukkala, A. and Kermanshachi, S. (2021). Impact of covid-19 on field and office workforce in construction industry. *Journal of Project Leadership and Society*. doi: 10.1016/j.plas.2021.100018

Permesly, P., Bellack, B., Stamp, M. and Wright, W. (2021). The impact of COVID-19 on construction and infrastructure projects: an on-site perspective. Arps, Slate, Meagher, Flom, LLP and Affiliates, New York.

Rouhanizadeh, B., Kermanshachi, S. and Nipa, T.J. (2019). Identification, categorization, and weighting of barriers to timely pos-disaster recovery process. *computing in Civil Engineering 2019: Smart Cities, Sustainability, and Resilience*, American Society of Civil Engineers Reston, 41-49, doi: 10.1061/9780784482445.006.

Salami, B.A., Ajayi, S.O. and Oyegoke, A.S. (2021). Tackling the impacts of Covid-19 on construction projects: an exploration of contractual dispute avoidance measures adopted by construction firms'', *International Journal of Construction Management*. doi: 10.1080/15623599.2021.1963561.

Shank, G. D. (2006). *Qualitative Research's* Personal Skill Approach, Pearson Merill Prentice Hall, Upper Saddle River, New Jersey.

Simpeh, F. and Amoah, C, (2021). Assessment of measures instituted to curb the spread of COVID-19 on construction sites. *International Journal of Construction Management*. doi: 10.1080/156235992021.1874678.

Thapa, P., & Shrestha, S.K. (2021). Assessment of the impact of COVID-19 Lockdown on Nepal's Construction Sector Based on Selected Construction Projects. *Journal of Advance Research in Civil and Environmental Engineering*, 8, 1-9

Timilsina, S.P., Ojha, S.K. and Dhungana, B.R. (2021). Impact of covid-19 on construction industry of Nepal. *Journal of Modern Economy*, 12, 1232-1244, doi: 10.4236/me2021.128064.

Umar, T. (2021). The impact of COVID-19 on the GCC construction industry. *International Journal of Service Science, Management, Engineering and Technology*, 13, 1-7, doi: 10.4018/IJSSMET20220301.oa1.

WHO (2020), Origin of SARS-COV-2, World Health Organization, available at: https://apps.who.int/iris/bitsstream/handle/10665/332197/WHO-2019-nCoV-FAQ-Virus_origin-2020.1-eng.pdf

Yadeta, A.E. and Pandey, D. (2020). Analysis of the global impact of the pandemic (Covid-19) on construction industry: possible scenarios'', *Current Trends in Civil and Structural Engineering*, 6, pp.1-8

Performance of Housing Cooperatives Societies in Housing Finance in North Western Geo-Political Zone, Nigeria

Aliyu, A.[1a] & Ganiyu, B. O.[1b]
[1]*Department of Quantity Surveying, Federal University of Technology, Minna.*
qsadamu51@gmail.com; bashiroganiyu@futminna.edu.ng
Corresponding email: qsadamu51@gmail.com

Abstract:

Housing is widely acknowledged as one of life's most fundamental requirements and a requirement for man's existence. In view of this, the study assessed the performance of housing cooperatives in housing finance in north western Nigeria with a view to providing affordable housing. Data was collected from 150 members of the FRSC Staff Housing Cooperative, the Staff of the Kaduna State Housing Cooperation, and NNPC Staff Multi-Purpose Cooperative Societies. Simple random sampling technique was adopted for the study. The analysis of the data was carried out with the use of percentage, mean item score, and Pearson product correlation. The findings revealed that the major sources of funds for the sampled housing cooperative societies for housing provision are through member contributions and development levies. The most widely adopted mode of operation for housing development is the provision of loans, with a mean value of 4.80. The correlation between the performance of housing cooperatives in housing finance and their mode of operation for housing development was found to be significant at 5% (0.05) level of significance (p = 0.36). It was concluded that the success rate of cooperative societies in housing provision is average, dispelling the belief that cooperative approach to housing delivery is a sure way of arresting the problem of housing availability. The major recommendation from the study was that in order for cooperative societies to be successful in housing intervention, they must increase their financial capacity and operational funds as well as handle the different obstacles that they face.

Keywords: Cooperatives, Finance, Housing, Housing availability, Performance.

Introduction

Housing is widely acknowledged as one of life's most fundamental requirements and a requirement for man's existence (Akinsanya & Adewusi, 2017). It is one of the most essential indicators for gauging a country's welfare because of its capacity to increase its inhabitants' health and well-being and development of the country economy (Ayeniyo, 2015). While adequate housing is crucial for every person and country, the housing crisis continues to be a worldwide issue and a growing difficulty for both urban and rural people, especially in most emerging nations. In the previous one hundred years, Nigeria has seen a high pace of urbanization (Abdulkareem, *et al.*, 2020), resulting in an exponential population increase in existing urban centers and the emergence of new ones.

However, Nigeria now has a housing gap of approximately 17 million units and need to add roughly 700,000 new units per year for the next 20 years to make up the shortfall (Olugbenga et al, 2017). These figures indicate that Nigeria has a significant housing shortage. Finance is a necessary component of housing supply and is often seen as the lifeblood of real estate development. Any successful and long-term housing program depends on the availability of funds for the housing project. The way cities are built is a direct reflection of how they are funded in terms of housing (Nubi, 2012).

For example, Garba et al (2021) reasoned that when the housing financing system is well-structured, the city will look well-organized with well-built residences. However, housing is a local and long-term commodity, domestic resource mobilization via savings to finance construction of shelter is extremely important. As a result, the task is to formalize and integrate alternative funding mechanism into the official financial system (Olayinka *et al.*, 2016). Cooperative societies are democratic structures in which people work together to meet their social and economic needs (Oyalawo & Babawale, 2017). Cooperative societies are seen as an economic instrument since they may create savings that commercial finance organizations need in order to provide house financing (Mahmud, 2015). Cooperative societies' efforts show how self-help can solve a wide range of socioeconomic issues. These views are supported by Ayedun, et al, (2017) research on cooperative activities in the Lagos Metropolis. Furthermore, experts on cooperative housing have acknowledged that cooperative societies should have a more defined role in housing financing and supply (Olayinka et al., 2016, cited in Mazadu et al, 2021).

It is within this perspective that this research narrowed down its focus to assess the performance of housing cooperatives in housing finance in North western Nigeria, with emphasis on Kaduna State. In order to achieve this aim, the following objectives were formulated; evaluate the factors that influencing the performance of housing cooperatives in the study area; and to determine the level of satisfaction with the strategies adopted by the cooperative's societies in housing provision.

Literature Review

The pooled effect of high population upsurge and urbanisation in a declining economy has thrown Nigeria into serious housing problems. Ironically, the low-income groups that constitute the majority of Nigerian society are the most affected by the financial menace. The problem of housing shortages is growing worse by the day in many developing nations, including Nigeria. Conceivably, a major trait of the housing crisis notable in urban centers in most developing nations is that of inadequate supply relative to demand. A shortage of adequate housing virtually abounds in every country, particularly in the developing and third-world countries. The shortage, in both quantitative and qualitative terms, is more acute in urban centers. Thus, it is assertive that there is inadequacy in housing to cope with the ever-increasing population in Nigeria. The causes of this dearth in housing are numerous. High construction costs are found to be present in all countries, albeit to varying degrees of significance. Adedeji (2010) attributes the high cost of construction to the rising cost of building materials, the inflation rate in the economy, the high space and quality standards adopted by designers, professional fees for housing design and construction, excessive profit of contractors, and 10% interest payable on the National Housing Fund in Nigeria (NHF).

Moreover, several studies (Farouk, 2014; Olayinka, 2016; Ayedun *et al*, 2017) have evaluated cooperative societies, housing provision, and housing finance in different parts of Nigeria. Each of these studies attempted to identify challenges faced by cooperative societies in housing provision from the perspective of resident satisfaction. The first limitation of the above referenced studies is that, the data used in the studies were collected from selected cooperative societies on their contribution to meeting the housing needs of their members. Secondly, the residents' perceptions of the level of performance of the various housing cooperative societies in housing provision were also used. However, none of those studies focused on Kaduna State or any cooperative housing estate within the north western geopolitical zone of Nigeria. It is for this reason that this research sought to evaluate the performance of housing cooperatives in financing housing in Kaduna State, Nigeria.

Factors Influencing the Performance of Housing Cooperatives

Despite the potentials and the important contributions of housing cooperatives and self-help groups to housing delivery, certain problems hamper their effective operation. It is noted that the contributions of the informal sector in the production of residential housing have been quite obvious over the years, but for the past two decades or so, when the public sector became more active in housing production, the importance of the informal sector has been on the decline. Among others, the problems that militated against the housing production and delivery efforts of the informal organizations include:

1. Low government support, recognition and inadequate operating environment. Although the 1991 housing policy seeks to mobilize private sector participation in housing provision, the cooperative option has not been explored in practical terms and there has been no adequate supportive environment for it to thrive.
2. Only few people have realized the potentials of self - help and housing cooperatives in housing delivery. People have not been adequately sensitized and mobilized to form cooperatives to meet their housing needs.
3. Financial constraints and the inability of the societies to secure loan or mobilize enough finances from members have been a constraint to the informal housing delivery system. Experience from the Asian countries shows that they do not know how to obtain and manage a mortgage loan. Very often, available savings are used for site acquisition and members have no money left with which to begin construction (Lewin, 1981).
4. Members are not adequately knowledgeable in housing management and administration particularly on technical aspect of building and financial management, e.g., bookkeeping. This often led to poor project supervision, control and financial irregularity.
5. Lack of adequate technical support and facilitation to aid cooperative housing delivery efforts. Most self-groups and housing cooperatives do not receive adequate technical guidance or assistance in their building projects due to poor operating environment. There is often the absence of private, semi-governmental or governmental Technical Service Organisation (TSO) to assist the existing housing cooperatives in project planning, financial administration and supervision of their housing schemes.
6. Problem of land acquisition for housing project development. problem of land ranges from delay in title\certificate of occupancy acquisition and plan approval, land speculation leading to high-cost litigation in case of multiple sale of the same land to different people general inadequate access.
7. Changes in Policy Environment: Changes in government policy is a significant challenge facing co-operatives. Co-operative societies that had enjoyed a considerable amount of financial support of their governments at various times have had to adjust with much strain, 115 when government withdrew support in the face of harsh micro-economic turns. This is especially true for countries like Canada, Turkey, Austria, Poland and Czechoslovakia.
8. Macro-economic Policies: Related to the changes in government policy, the literature revealed that macro-economic policies have constrained housing supply by co-operative societies, since housing production costs generally increased as government withdrew from subsidies and the prices of housing and complementary services increased. This occurred in Poland, Canada, and Austria. This brought about financing challenges for the organizations. On the other hand, at periods of favourable macro-economic climate, cooperatives in countries such as Austria and Belgium enjoyed considerable development.
9. Regulatory Environment: In addition, Saegert and Benitez (2004) maintains that lack of innovative financing options and strict regulatory mechanisms are some challenges in developing and operating low-income housing by co-operative societies. This was evident in almost all countries and several such as Austria and Belgium put in direct policy measures to address this.

Level of Satisfaction with the Strategies Adopted by the Cooperatives Societies in Housing Provision

Satisfaction is the person's feelings of pleasure or disappointment from comparing a product's perceived performance (or outcome) to their expectations (Dakurah *et al.,* 2005). This definition makes it clear that satisfaction is a function of perceived performance and expectations. If the performance falls short of expectations, the cooperator is dissatisfied; if the performance matches the expectations, the cooperator is satisfied. If the performance exceeds expectations, the cooperator is highly satisfied or delighted (Dakurah *et al.,* 2005). Olayinka *et al.* (2016) asserted that cooperators satisfaction is a precursor of improved performance and cooperator retention for any cooperative society. In part, the strength of a cooperative depends on its ability to mobilise its resources and members in gaining market share and achieving economic growth and maintaining member commitment, satisfaction, and retaining them. Satisfied, highly committed members are more likely to support their cooperative by participating in all cooperative activities. The reverse occurs when members are unhappy. Member's goals, what they desire from their cooperatives are critically related to why they joined the cooperative in the first place. These goals also affect member satisfaction with the cooperative, commitment to it, and participation in its activities (Dakurah *et al.,* 2005).

The ability of a cooperative to meet its members' expectations depends on whether management effectively evaluates membership needs. Often, they do not, and there are several reasons for this. One notion is that of "assumed similarity," cooperative official's belief that the interests of the general membership must be similar to their own and, therefore, there is no need to investigate them separately. Secondly, member official communications may be poor (Bello, 2005). The third is reported by (Mazadu *et al*, 2021), as a divergent set of members objectives both between and within cooperatives, members' attitudes towards their cooperatives significantly impact their participation and behavioural intentions. Odhiambo (2003), opined that various internal and external factors might influence the level of member satisfaction. However, the more positive attitude one holds towards an organisation, the more likely it is that the person will patronize or use a service from it.

According to Olanda (2006), achieving high levels of cooperators satisfaction requires cooperative society to continually monitor and examine the experiences, opinions, and suggestions of their cooperators and other people who are likely to be potential members, as democratic organisations, to encourage cooperators patronization for the realization of their distinctive character. Farouk *et al.* (2014) reported that cooperators expressed their satisfaction with housing cooperative loans compared to the National Housing Fund. Gbadeyan (2011) also revealed that cooperators expressed satisfaction with an interest rate, affordability, transaction cost, availability and collateral for housing finance. However, in housing activities, cooperators need to be satisfied with housing development, cost of labour, building materials purchased, houses directly purchased, interest to be paid on loans for housing, cost of loan recovery if members default, transaction cost, processes of land and building document, land allocated and so on.

Research Methodology

A quantitative research approach was adopted in this study. The use of structured questionnaires was employed for data collection in order to achieve the study's objectives. The mean item score (MIS) and spearman rank correlation were used to analyse the collected data. The population for this research was drawn from the list of the members of FRSC Staff Housing Cooperative, Staff of Kaduna State Housing cooperation and NNPC Staff Multi-Purpose Cooperative Society Limited. Fifty (50) members each from FRSC Staff Housing Cooperative, Staff of Kaduna State Housing cooperation and NNPC Staff Multi-Purpose Cooperative Soc. Ltd were purposively selected. Therefore, a total of 150 members from all the three aforementioned cooperatives societies were sampled for this study.

Results And Discussion

Factors that influence the performance of housing cooperatives in the study area

The use of MV was used to rate the factors that influence the performance of housing cooperatives in the study area. The result of the MV analysis is presented in Table 1.

Table 1: Factors influencing the performance of housing cooperatives

Factors	**Mean**	**Rank**
Financial stability	4.67	1st
Management Competency	4.50	2nd
Leadership	4.48	3rd
Market competition	4.00	4th
Organization structure	3.85	5th
Computerization	3.60	6th
Personnel	3.00	7th
Average MIS	***4.01***	

It was shown that the most influential factors are financial stability, management competence, and leadership, with MV values of 4.67, 4.50, and 4.48 ranked 1st, 2nd, and 3rd, respectively. The personnel factor was identified to be the least influential factor, with a mean value of 3.00 ranked 7th. On average, all the identified factors influence the performance of housing cooperatives in the study area (average MIS = 4.01).

Influence of Management Competency on Performance Housing Cooperative Society

Table 2 reveals the influence of management competency on performance in a housing cooperative society. The findings show that management competency influences the actualization of the society's objectives (MV = 4.50 ranked 1st), while encouraging more members to join was ranked 2nd (MV = 3.80) and having little impact was ranked 3rd (MV = 2.65).

Table 2: Influence Management Competency

Management competency	**Mean**	**Rank**
Influences Actualization of the society objectives	4.50	1st
Encourages more members to join	3.80	2nd
Has little impact	2.65	3rd

Influence of Personnel on Performance of Housing Cooperative Society

The findings revealed that, all four personnel influences identified, which are: encouraging more members to join; improving professionalism; connecting the board and the members; and providing skilled services (MV = 4.50 and 4.50 ranked first; MV = 4.00 and 4.00 ranked third and fourth), were significant.

Table 3: Influence of Personnel on Performance of Housing Cooperative Society

Personnel	**Mean**	**Rank**	**Decision**
Encourages more members to join	4.50	1st	Very significant
Improves professionalism	4.50	1st	Very significant
Link the Board and the members	4.00	3rd	Significant
Gives skillful services.	4.00	4th	Significant

Influence of Computerization on Performance Housing Cooperative Society

The findings show the influence of computerization on performance in housing cooperative society. The findings show that computerization influences It reduces errors and improves efficiency of cooperatives in general business and creates more confidence with a MV = 4.50, 4.30, 4.00, and 3.80 (ranked 1st, 2nd, 3rd, and 4th) respectively are of extent.

Table 4: Influence of Computerization on Performance Housing Cooperative Society

Computerization	**Mean**	**Rank**
Reduces errors	4.50	1st
Improves efficiency	4.30	2nd
Improves cooperatives general business	4.00	3rd
Creates more confidence	3.80	4th

Influence of Financial Stability on Performance of Housing Cooperative Society

Table 5 reveals the influence of financial stability on the performance of housing cooperative societies. The findings show that financial stability influence includes making the cooperatives meet their obligations; members' loan demand is attended to on time; members' confidence is built; and experiencing fewer liquidity problems with a MV = 4.80, 4.50, 4.40, and 4.10 (ranked 1st, 2nd, 3rd, and 4th) respectively are of extent.

Table 5: Influence of Financial Stability on Performance of Housing Cooperative Society

Financial Stability	**Mean**	**Rank**
Make the cooperatives meet her obligation	4.80	1st
Members loans demand is attended on time	4.50	2nd
Members confidence is built	4.40	3rd
Experience less liquidity problem	4.10	4th

Level of Satisfaction with the Strategies Adopted by the Cooperatives Societies in Housing Provision

The use of MV was used to rate the level of satisfaction with the strategies adopted by the cooperative societies in housing provision. The result of the MV analysis is presented in Table 6. It was shown that the members were very satisfied with the saving and deposit mobilization policy of the Co-operative Society, with an MV of 4.50 ranked 1st, followed by satisfaction with the amortization period for housing loans, with an MV of 4.38 ranked 2nd. With MVs of 4.20 and 4.10, respectively, ranked 3rd and 4th, the members of the cooperative society were very happy with the interest rate on loans and the way loans were given out and paid back. The findings of the study agree with the Gbadeyan (2011), where it was revealed that cooperators expressed their satisfaction with an interest rate, affordability, transaction cost, availability and collateral for housing finance. However, in housing activities, cooperators need to be satisfied with housing development, cost of labour, building materials purchased, houses directly purchased, interest to be paid on loans for housing, cost of loan recovery if members default, transaction cost, processes of land and building document, land allocated etc.

Table 6: Level of Satisfaction with the Strategies Adopted

Level of Satisfaction	**Mean**	**Rank**
Are you satisfied with the saving and deposit mobilization policy of the Co-operative Society	4.50	1st
Are you satisfied with amortization period for housing loan obtained	4.38	2nd
Are you satisfied with interest charge on the loan	4.20	3rd
Are you satisfied with the loan lending and recovery process of the Co-operative society?	4.10	4th

4.7 Hypothesis

H_0: There is no significant relationship between performance of housing cooperatives in housing finance and mode of operation for housing development.

H_1: There is a significant relationship between performance of housing cooperatives in housing finance and mode of operation for housing development.

To test these hypotheses, correlation analysis was performed and the results indicate that there is a weak positive relationship between performance of housing cooperatives in housing finance. The pearson correlation coefficient, r, is 0.253, and that, it is statistically significant (p = 0.036). Therefore, the alternate hypothesis that states a significant relationship exists between performance of housing cooperatives in housing finance and mode of operation for housing development was accepted (r = .253, n = 150, p = .036).

Table 7: Results of Pearson Product Correlation Analysis

Correlations		performance of housing cooperatives	mode of operation
Performance of housing cooperatives	Pearson Correlation	1	.253*
	Sig. (2-tailed)		.036
	N	150	150
Mode of operation	Pearson Correlation	.253*	1
	Sig. (2-tailed)	.036	
	N	150	150

*. Correlation is significant at the 0.05 level (1-tailed).

Conclusion And Recommendations

Co-operative societies' actions in housing supply are required due to the capital-intensive nature of housing and the widespread housing demand in Nigerian cities, as well as the government's ineffective involvement. However, the extent of their operations and the unique characteristics of their market have gone unrecorded. In order to assess cooperative societies' approaches to providing housing within the reach of low-income members of the cooperatives in North West Nigeria. This study further concludes that there is weak positive relationship between performance of housing cooperatives in housing finance and mode of operation for housing development. Also, the success rate of co-operative societies in housing provision is average dispelling the belief that co-operative approach to housing delivery is a sure way of arresting the problem of housing provision.

In view of these conclusions the paper, recommends that the:

- The internal governance mechanism of co-operatives be strengthened for improved co-ordination.
- The academia should support the process of strengthening the internal governance of co-operative societies, while keeping relations with external stakeholders. This can be done by breaking down theories of co-operative governance into clear actionable points for the cooperative societies to adopt and the regulators to enforce.
- The cooperative societies should ensure that the procedures for granting such loan are not cumbersome and the interest rate on such loan is reduced or manipulated in favour of cooperators. This would go along to make funds available to the prospective beneficiaries of the cooperative loans.

References

Abdulrazzaq, L. R., Abdulkareem, M. N., Yazid, M. R. M., Borhan, M. N., & Mahdi, M. S. (2020). Traffic congestion: Shift from private car to public transportation. Civil Engineering Journal, 6(8), 1547-1554.

Akinsanya, G. M., & Adewusi, A. O. (2017). Staff Housing needs of Nigerian University: A case of Obafemi Awolowo Univeristy, Ile-Ife. IIARD International Journal of Geography and Environmental Management, 3(1).

Ayedun, C. A., Oloyede, S. A., Ikpefan, O. A., Akinjare, A. O., & Oloke, C. O. (2017). Cooperative Societies' Housing Provision and Poverty Alleviation in Nigeria. Covenant Journal of Research in the Built Environment, 5(1), 69–81

Ayeniyo, O. (2015). Housing Finance in Urban Areas of Nigeria: An Empirical Example from Akure, *Ondo State* Swift Journals of Social Sciences and Humanity, 1(1), 008-012. Daniel, M. M. (2014). Interest Groups and Housing Provision in Nigeria: A Review Study. Journal of World Economic Research

Bello, A. (2005). The Role of Cooperative Societies in Economic Development. Retrieved from https://mpra.ub.uni-muenchen.de/23161/1/MPRA_paper_23161.pdf

Dakurah, H.A., Goddard, E. and Osuteye, N. (2005). Attitudes towards and Satisfaction with Cooperatives in Alberta: A Survey Analysis. Selected Paper Prepared for Presentation at the American Agricultural Economics Association Annual Meeting, Providence, Rhode Island.

Farouk, A., Ikram, A., & Sami, B. (2014). The influence of individual factors on the entrepreneurial intention. International Journal of Managing Value and Supply Chains, 5(4), 47-57.

Farouk, B. U. K., David, I. J., & David, O. A. (2014). Savings and Credit Cooperative Societies (SCCs): A Panacea to Accessing Funds for Housing Development to Workers of Public Institutions in Nigeria. Journal of Economics and Sustainable Development, 5(23), 135–148.

Garba, D., Iroaganachi, N., & Bala, I. (2021). Factors Determining Cooperative Societies' Housing Finance Acceptance in Gombe, Nigeria. Traektoriâ Nauki= Path of Science, 7(9), 1007-1012.

Gbadeyan, R.A. (2011). Private sector's contributions to the development of the Nigerian housing market. Current Research Journal of Social Sciences, 3(2): 104-113.

Lewin, A. C., (1981). Housing Cooperatives in Developing Countries, USA

Mazadu, A. A., Muhammad, M. S., & Iroaganachi, N. (2021). Cooperators Satisfaction with Cooperative Society Housing Activities in Jos. Traektoriâ Nauki= Path of Science, 7(8), 3007-3015.

Mahmud, S. M (2015). An Evaluation of the Contributions of Cooperative Societies in Housing Finance to Workers of Tertiary Institutions in Zaria Metropolis. Retrieved from https://projectchampionz.com.ng/2020/05/06/an-evaluation-of-the-contributions-ofcooperative-societies-in-housing-finance-to-workers-of-tertiary-institutionsin-zariametropolis/

Nubi, T. O. (2012). Towards a Sustainable Housing Finance in Nigeria: The Challenges of Developing Adequate Housing Stock and a Road Map. Housing Finance International, 24(4), 22–29.

Odhiambo, B. (2003). Determinants of customer satisfaction for mobile phone subscribers in Nairobi (Master's thesis). Retrieved from http://erepository.uonbi.ac.ke/bitstream/handle/11295/22154/Odhiambo_Determinants%20of%20Customer%20Satisfaction%20for%20Mobile%20Phone%20Subscribers%20in%20Nair obi.pdf; sequence=3

Olanda, J. (2006). Leadership Behaviour, Job satisfaction, Organisational Commitment, Service Quality and Customer Satisfaction in manufacturing sector (Master's thesis), University of Nairobi, Kenya

Olayinka, C. O., Samuel, A.O. & Olufemi, D. D. (2016). Empirical Determination of Cooperative Housing Intervention Methods in Lagos Metropolis. Covenant Journal of research in the Built Environment, 4(1), 49–66.

Olugbenga, T. D., Yusoff, N., Abd Aziz, N., & Baba, A. N. (2017). Unleashing the potentials of housing sector in Nigeria as perceived by users. International Journal of Built Environment and Sustainability, 4(3).

Oyalawo, B. A., Babawale, G. G. (2017). Urban Housing Supply: Cooperative Societies as the Third Way. Retrieved from https://ir.unilag.edu.ng/bitstream/handle/123456789/3919/Urban%20Housing%20Supply%20Cooperative%20Societies%20as%20the%20Third%20Way.pdf?sequence=1&isAllowed=y

UNCHS (United Nations Centre for Human Settlements - Habitat) (1989). Cooperative Housing: Experiences of Mutual Self Help, Nairobi

Saegert, S., & Benitez L., (2004). Limited equity housing co-operatives: defining a niche in the low-income housing market. Journal of Planning Literature, 2005 (19), 427-438.

UNCHS (United Nations Centre for Human Settlements - Habitat) (1989). Cooperative Housing: Experiences of Mutual Self Help, Nairobi

Influence of Risk Factors on Transnational Public Private Partnership Cost Performance

Waziri, A.[1a], Musa, M. [1b] & Faruq, I.[1c]
[1]Abubakar Tafawa Balewa University, Bauchi, Department of Quantity Surveying.
[a]aywaziri@gmail.com; [b]mmmukhtar99@gmail.com; [c]idwoufaruq@gmail.com;
corresponding author: aywaziri@gmail.com

Abstract:

Given the increased demand for public facilities and the lack of funds and skills to maintain, repair, replenish the existing facilities, and construction of new megaprojects infrastructure, Using Transnational Public Private Partnership is an innovative way to establish transnational cooperation and global support. However, despite the array of benefits of Transnational Public Private Partnership project, risk factors still influence the collaborative adoption of Transnational Public Private Partnership project performance, due to its uniqueness and complexity, and thus hinder the performance of the project. The aim of the research is to assess the influence of risk factors on Transnational Public private Partnership Performance. Data for the research were obtained through quantitative methods approach. A well-Structured Questionnaires were self- administered on five different stakeholders; comprised public sector authorities (i.e., ministries, department, and agencies), Shareholders, Sponsors/Financiers/banks, consultants, and contractors involved in the TPPP projects in Nigeria. 63% response rate was achieved and used for the analysis. The data collected were analysed using descriptive and "Partial Least Square-Structural Equation Modelling" (PLS-SEM). The study further shows that there is significant positive relationship between Construction Risk; Cooperation with Public and Private Risk; Economic and Financial Risk; Legal Risk; Nature/Environmental Risk; Operation Risk; Political Risk; Technology Risk and TPPP Project (Cost) Performance, meanwhile the relationship between Tariff Risk factor and TPPP Project Cost Performance was statistically not significant. Hence, stakeholders in the Nigerian TPPP should develop strategies to eliminate these risks towards ensuring successful implementation of TPPPs in Nigeria.

Keywords: Cost Performance, PLS-SEM; Risk factor; Transnational Public private Partnership; Nigeria.

INTRODUCTION

Infrastructure has been identified as a catalyst for economic growth. Thus, Public Private Partnership (PPP) is a credible vehicle for the development of the Nation's infrastructure. The involvement of the private sector in the development and financing of public facilities and services has increased substantially over the past decade (Li, Akintoye, Edwards and Hardcastle, 2005a; (Onyemaechi and Samy, 2016; Iloh and Muktar, 2013).

PPP improve public services in quality and effectiveness and to make operations more efficient, public-private partnerships (PPP) have emerged as a strategic instrument in industries and educational sectors; they are pursued by public and commercial service providers teaming up and pooling complementary knowledge, skills and resources over a longer period of time. Public Private Partnership (PPP) arrangements have become a global trend for providing a public asset or service in the early 1980s an unrealistic or more like a novel procurement alternative (World Bank, 2014). As time goes by, PPP moved from trend to become an important method of financing government infrastructure and have made an important contribution to the development of public infrastructure and service projects through the reduction of the financial pressure on government and improving the efficiency of project performance (Ibrahim, Price, and Dainty, 2006; Adepetun, 2016; Siyanbola, 2018). Moving from the global scene to developing countries, the population growth is seriously outstripping the capacity of most governments especially, in the provision of adequate infrastructure for their citizens. However, the population is projected to increase by 2.5 billion people by 2050, with nearly 90% of the increase is expected in the developing countries of Asia and sub-Saharan Africa which are the poorest regions in the world (United Nations, 2014; Muhammad and

Johar, 2018). These regions are facing a great financing and technical needs for provision of megaproject infrastructure, such as highways, power plants, dams, bridges, airports, and telecommunication networks. These require advanced technologies and a huge amount of money, which most developing countries do not have the capacity to fund. This is what opened the way for Transnational Public Private Partnership (TPPP) as an innovative way to establish transnational cooperation and global support (Trumbull, 2009; Agrawal, 2010; Luiz, 2010; Roumboutsos and Macario, 2013; Muhammad and Johar, 2018).

Transnational PPP (TPPP) is an inevitable concept for global infrastructure and investment in the construction industry because it is a crucial way for developing countries to attract foreign investors to address the huge financing gap and enhance the efficiency of capital allocation, or "transnational" refers to PPPs involving actors in different countries. Transnational PPP is not only across-national business strategy but also an important way to learn about advanced methodologies on how to run PPP projects for countries without relevant experience.

According to Yu et al. (2018) foreign investors remain sensitive to risks which could serve as the drivers to successful implementation of TPPP projects. However, despite the array of benefits of TPPP project, risk factors still influence the collaborative performance of TPPP project, due to its uniqueness and complexity, and thus hinder the performance of the project. Yu et al. (2018) and Siyanbola (2018) identified few risk factors affecting the TPPP implementation, However, there is no research efforts on the influence of risk factors on TPPP Cost Performance, as well as the extent of those risk factors, towards achieving a successful TPPP project is Nigeria construction Industry.

Nonetheless, understanding public and private organisations' capability to sufficiently manage TPPP project risks factors, may help bridge the knowledge gap between Transnational partnership expectations and the way these are fulfilled. Although the study further stressed that the risks are presented throughout the TPPP process, but the risk could be overcome and managed.

As a result, very little is known of the influence of these risk factors associated with TPPP cost performance in the Nigerian construction industry. The aim of the research is to assess the influence of risk factors on TPPP Cost Performance, thus; to establish the relationship between risk factors and TPPP Cost Performance in construction projects and to determine the impact of risk factors on TPPP Cost Performance in construction projects.

The study chooses Lagos as a study area because of the following reasons: accessibility to conduct the survey to obtain required data; availability of substantive TPPP experts; and appropriateness of the TPPP infrastructure project for the analysis. This study will focus on the major role players in the execution of the TPPP projects, government representatives from related departments, contactors, shareholders, consultants and sponsors/ financiers/banks.

2.0 LITERATURE REVIEW

2.1 Concept of Transnational Public Private Partnership (TPPP)

Infrastructure development is closely related to economic growth in both developed and developing countries. Thus, ensuring that infrastructure projects are successfully and efficiently developed should be a top priority in economic development in all countries (Underhill and Zhang 2008; Babatunde, 2015). However, Megaproject infrastructure, such as highways, power plants, dams, bridges, airports, and telecommunication network, requires advanced technologies and a huge amount of money. These advanced technology and financial capacity are what most developing countries do not have that made TPPP a good solution to these problems (Yu et al., 2018). Most of the countries included in this strategy are developing countries with relatively insufficient funds in infrastructure and infrastructure development is closely related to economic growth in both developed and developing countries. Thus, ensuring that infrastructure projects are successfully and efficiently developed should be a top priority in economic development in all countries (Underhill and Zhang, 2008). Which is the reason why more TPPP infrastructure project needs to be welcomed and its risks considered because in TPPP, risks are bound to increase with foreign penetration due to unfamiliarity in the geography, the supply chain, the local legislation, and the business practices (Rebeiz, 2012).

The development of a good physical and social infrastructure is characterised by significant investment requirements. Thus, to avoid cost overrun, and benefit from innovative project structuring and implementation strategies, private sector participation in the development of infrastructure is extremely critical (Ernst & Young, 2012; Babatunde, 2015). Many studies have been conducted regarding governments' inability to raise massive funds for large-scale infrastructure projects that can be mitigated by foreign investors participation (Cheung et al., 2009; Huasheng, 2016). Foreign investors participation is preferable if the country lacks resources to deliver important public services such as healthcare, transportation, energy (Wibowo and Alfen, 2015).

2.2 Cost Performance in Transnational Public Private Partnership (TPPP)

Cost Performance is simply a measure of the degree to which general conditions promote the completion of a construction project within the estimated budget. It is measured by comparing current costs allocated for the work against budgeted costs allocated for the work in place, completed to date (Vyas & Kulkarni, 2013). Although cost is not limited to tender sum alone but includes all the cost incurred from inception to completion (Chan, 2013) but, events that leads to poor cost performance are usually associated with construction phase due to various uncertainties that characterise the phase of construction projects. Idrus et al. (2015) explained the importance of cost performance as a measure of project performance by linking it to client satisfaction. In measuring client satisfaction, delivery of desired quality project within estimated budgets and planned time are important. The criteria for measuring the cost performance of project are: *Project completion on budget* determines the cost performance on construction projects as these are likely to lead to exceeding the target or budget for the project (Anas, 2016).

These are the criteria influencing cost performance in the study of Anas, (2016), Osikhuemhe, (2017) and Bello, (2017), in their literature as shown in Table 1 as follows:

Table 1: Criteria influencing cost performance for TPPP Project

S/No	**Cost performance Criteria**	**Source**
1	Project completion on budget	Odeyinka et al. (2012) and Oboirien, (2019)

Sources: Anas, (2016) and Bello, (2017)

2.3 TPPP Project Performance and Project Risk

Before eliciting the literature to support the relationship between risk factor and project performance, there arises a need to define that what basically the project is. The project is illustrated as: "A project is an endeavour in which human, financial and material resources are organized in a novel way to undertake a unique scope of work, of given specification.

Performance of the project is also measured by the project's emerging properties' ability to manage and cope with the risk level of the respective project (Zhu and Mostafavi, 2017) and there are many factors constituting towards risk factors of the project e.g. size, long-term duration, technical novelty, geographical difference, etc. and each of this factors has a negative impact on project performance (Williams, 1999; Sicotte and Bourgault, 2008; Um and Kim, 2018; Bosch-Rekveldt et al., 2011, Yu et al., 2018). There are many factors that contribute towards the complexity of the project and each of them are necessary to drive the project for success and needs to be managed in a way that risk can be minimized as possible (Nguyen et al., 2018); as scholars have validated that the risk of projects grows at a faster pace than the ability to cope up with that complex situation (Maylor and Turner, 2017). (Gidado, 2013) have developed an exclusive numerical model to measure the level and seriousness of risk factors as a quantifiable approach in order to know its effect on time and cost of the project, thereafter explaining risk as one of the important and inherent features of the project and affecting the performance based on the intensity of complexity and its respective impact on performance.

2.4 Risk Factors Associated with TPPP

Identification of risk factors in TPPP projects is the initial stage to achieve project success because the riskiness of TPPP result from a combination of risk factors that are naturally associated with the infrastructure procurement and those arising from private sector participation. Cheung and Chan (2011) stress that PPP projects require careful identification and analysis of risk factors that could adversely affect their success and this section reviews some of the studies that have worked on TPPP risk factors.

Table 2: TPPP risks identified from literature

S/No	Category of Risk in TPPP	Risk Identification	Sources
1	Tariff Risks	Market demand	Meduri and Annamalai (2013), Ritter (2010), Robeiz (2012), Tijhuis (2015), Wang et al. (1999), Wang et al. (2000), and Wibowo and Alfen (2015)
		Tariff/Price change	
2	Economic and Financial Risks	High inflation/increased price	Chou and Pramudawardhani (2015), Lobina (2005), and Wang and Tiong (2000)
		Delayed payments on contract	
		Volatility of interest rate	
		Poor cost control	
		Uncertainty over Foreign exchange and convertibility	
		Poor financial market	
3	Legal Risks	Legislation change/inconsistencies	Wang et al. (1999), Meduri and Annamalai (2013), Ritter (2010), Robeiz (2012), and Tijhuis (2015)
		Corruption and lack of respect for law	
		Change in tax regulation	
		Industrial regulatory change	
4	Cooperation with Public and Private Risk	Different working methods	Jang et al. (2014), Ke et al. (2010), Khalifa and Essaouabi (2003), Muller (2003), Ramakrishnan (2014), Ritter (2010), Robeiz (2012), Schäferhoff et al. (2009), and Smith et al. (2004)
		Inadequate experience in TPPP	
		Lack of commitment from public/private partner	
		Organization and coordination risk	
		Third party tort liability	
		Inadequate distribution of responsibility and risk	

5	Political Risks	Change in law	Jang et al. (2014), Ke et al. (2010), Khalifa and Essaouabi (2003), Muller (2003), Ramakrishnan (2014), Ritter (2010), Robeiz (2012), and Schäferhoff et al. (2009)
		Delay in project approvals and permits	
		Expropriation/nationalization of assets	
		Poor public decision-making process	
		Strong political opposition/hostility	
		Inconsistencies in government policies	
		Unstable government/withdrawal of government support	
		Political interference in procurement process	
6	Construction Risks	Excessive contract variation/contractual risk	Parola et al. (2013), Jang et al. (2014), Ke et al. (2010), Khalifa and Essaouabi (2003), Muller (2003), Ramakrishnan (2014), Ritter (2010), Robeiz (2012), Schäferhoff et al. (2009), and Smith et al. (2004)
		Construction time delay	
		Design deficiency	
		Geotechnical conditions/ground condition	
		Late design changes	
		Completion risk	
		Inadequately compensated variation order	
		Inadequate project program	
		Unforeseen site ground condition	
		Changes in government actions	
7	Technology Risk	lack of innovation in design	Appuhami et al. (2011), Babatunde et al. (2015), Bennett (1998), Choi et al. (2010), and Chou and Pramudawardhani (2015)
		lack of reliability and quality of the technical proposal	
		technological obsolescence	
8	Operation Risks	Residual value (after concession period)	
		Maintenance cost higher than expected	
		Low operating productivity	
		Risk regarding pricing of product/service	
9	Natural/Environmental Risks	Force majeure	Babatunde et al. (2015), Beisheim and Campe
		Environment	
		Weather condition	(2012), and Cocq and McDonald (2010)

Source: Buurman and Babovic (2017) and Babatinde, (2015)

3.0 RESEARCH METHODOLOGY

A quantitative approach was adopted for this research. A probability sampling using the random technique, which gives every construction industry professional equal opportunity to be selected (Olanrewaju et al., 2021). The target population includes public sector authorities (i.e government officials from related departments, contactors, consultants, Sponsors/ Financiers /Banks, and shareholders. This researcher contacted the Lagos State Transnational, Public Private Partnerships Office and Lagos State Development and Property Corporation (LSDPC) for determining the total population. This involves: Public sector authorities 45; Shareholders 15; Consultants 28; Contractors 35; and Sponsors/Banks/Financials 22 with the total population of 145. The entire population identified in TPPP infrastructure projects in the study area was sampled. This is supported by Fellows & Liu (2008) that if the population is sufficiently small, a full population sample may be considered. Data Collection was through Literature review and Questionnaire Survey in determine the influence of risk factors on TPPP Cost, performance in construction projects. Before data collection begins, a pilot study will be conducted to test the research instrument. The implementation of the pilot test helps researchers to reduce the ambiguity of a questionnaire by refining the content and meaning of questions. Following the advice of Newman (2003), the objectives of the pilot testing in this research were to: Ensure the face validity of the measurement variables, Ensure that sufficient detail is included in the survey Confirm the techniques is understandable to Respondents (Government officials from related departments, contactors, consultants, shareholders and sponsors/ financiers/banks), Ensure the relevance of the questionnaire items is to the targeted respondents in Nigeria thus reducing response bias.

Questionnaires will be distributed to Five (5) Risk experts in the academic area for pilot testing, as to tick/select the risk that are pertinent to the project and also to add the ones encountered and are not captured on the checklist. Descriptive analysis; The data obtained from the questionnaire survey were analysed using the Statistical Package for Social Sciences (SPSS 25.0) and inferential statistic (PLS-SEM) using SmartPLS3.

4.0 RESULTS AND DISCUSSIONS/DATA PRESENTATION AND ANALYSIS

4.1: Structural Equation Modeling (SEM)

SEM is a linear regression predictive tool used in construction management research. It is also commonly used to analyse complex relationships between variables or constructs simultaneously (Tabachnick et al., 2007). The measurement model must be validated through confirmatory factor analysis (CFA). The use of confirmatory factor analysis is to reduce measurement error by having multiple indicators per latent variable and increase the strength of the relationship between the variables, while conducting CFA, construct validity should be satisfied by using content validity and empirical validity tests. Once the measurement model is validated, the structural relationships between latent variables are estimated (Anderson and Gerbing, 1988; Garver and Mentzer, 1999; Babatunde et al., 2015).

4.2: An Evaluation of Risk Factors for TPPP Cost Performance

Confirmatory factor analysis (CFA) is used to establish confidence and strength in the measurement model. According to Chinda & Mohamed (2008). This study executed CFA to check standardized factor loading, validity and reliability of the variables and concepts. Table 3 and Figure 1 shows the measurement model, where all the items presented are related to their specific constructs with outer loading of the construct which is denoted as "Factor Loading, Cronbach alpha (α), Composite Reliability (CR) and Average variance extracted (AVE) for the model.

Table 3: Construct reliability and Validity: Initial Model

C	Construct	CODE	Factor Loading	Cronbach Alpha	Composite Reliability	Average Variance Extracted (AVE)
A	Tariff Risk	TARF01	0.863	0.450	0.711	0.591
		TARF02	0.578			
B	Economic and Financial Risk	ECOFIN01	0.718	0.421	0.601	0.520
		ECOFIN02	0.120			
		ECOFIN03	0.659			
		ECOFIN04	-0.368			
		ECOFIN05	0.203			
		ECOFIN06	0.145			
C	Legal Risk	LGL01	0.664	0.390	0.460	0.410
		LGL02	-0.384			
		LGL03	0.809			
		LGL04	0.248			
D	Cooperation with public and private Risk	CPP01	0.076	0.460	0.569	0.450
		CPP02	-0.396			
		CPP03	-0.526			
		CPP04	0.036			
		CPP05	0.686			
		CPP06	0.472			
E	Political Risk	POL01	0.616	0.694	0.746	0.554
		POL02	0.425			
		POL03	0.432			
		POL04	-0.203			
		POL05	0.595			
		POL06	0.143			
		POL07	0.572			
		POL08	0.434			
F	Construction Risk	CONST01	-0.118	0.521	0.672	0.518
		CONST02	0.263			
		CONST03	-0.709			
		CONST04	-0.103			
		CONST05	0.654			
		CONST06	0.236			
		CONST07	0.300			
		CONST08	-0.276			
		CONST09	-0.201			
G	Technology Risk	TECH01	-0.435	0.550	0.610	0.481
		TECH02	0.646			
		TECH03	0.719			
H	Operation Risk	OPR01	-0.155	0.380	0.420	0.350
		OPR02	0.247			
		OPR03	0.897			
		OPR04	-0.380			
I	Nature/Environmental Risk	NANEV01	0.936	0.510	0.600	0.421
		NANEV 3	0.249			
		NANEV02	0.497			
J	TPPP Project Performance (Cost)	COST	1.000	1.000	1.000	1.000

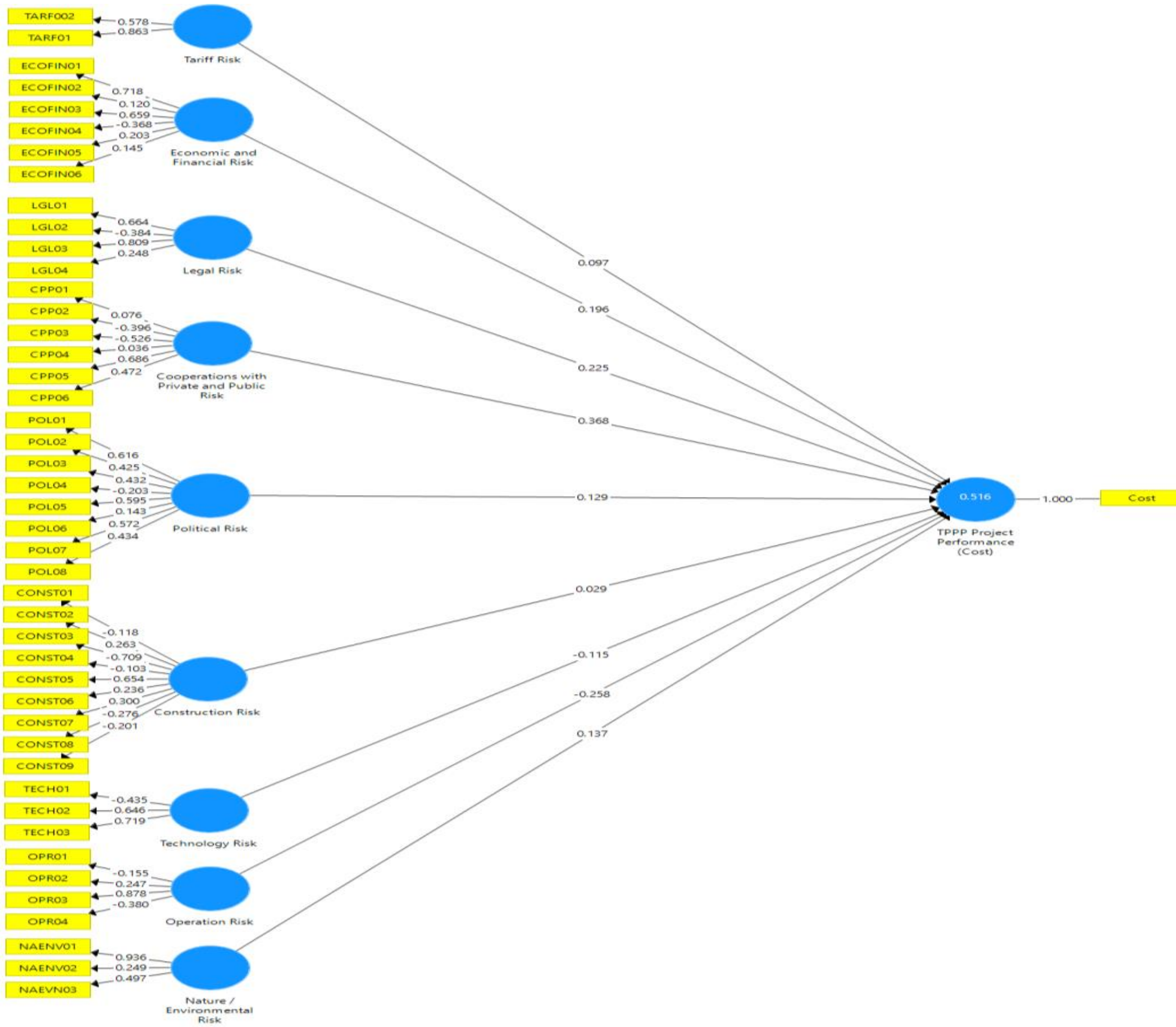


Figure 1: Initial Measurement Model for TPPP Cost Performance

From Table 3, the outer loadings ranged between -0.709 and 0.936, while the outer loading below 0.5 were deleted. The Table 3 shows all the Factor loading of each indicator that are below and higher than 0.500. In PLS, loadings of respective factors on their respective latent constructs are examined to assess the reliability of the factors, from these initial models, the final model will be decided after dropping out insignificant factors having factor loadings of less than 0.500 (Hair et al. 2011; Kineber et al. 2021b). For this study, the cut-off value for the outer loading was 0.500 as adopted previous study. *Cronbach's Alpha and Composite Reliability (CR)* were also used for internal consistency evaluation in the construct reliability. Nevertheless, compared to the Cronbach's Alpha, CR is believed to be a better assessment of internal consistency as it retains the standardized loadings of the observed variables (Lornell and Larcker, 1981; Anwar, 2018).

Table 3 further shows that the Cronbach's Alpha and CR for all constructs range were between 0.380 to 0.694. Thus, the Cronbach's alpha and CR showed that the scales were not reasonably reliable and indicated that all the latent construct values below the minimum threshold level of 0.700. *Average Variance Extracted*

(AVE): To verify the convergent validity of the variables, each latent construct's Average Variance Extracted (AVE) was calculated (Lornell and Larcker, 1981). The lowest 50% of the variance from the observed variable should be taken by the latent constructs in the model. Hence, this indicates that the AVE for all constructs should be above 0.500 (Ringle, Sarstedt, 2011; Barclay, Thompson, Higgins, 1995), above 0.500 is recommended, as observed in previous studies (Wong 2013; Olanrewaju et al. 2022).

Furthermore, Figure 1 shows the outer loading of the constructs which is denoted as 'Loading'. As part of the initial measurement model evaluation, Figures 1 highlight the initial models, showing the total Forty-five variables with their outer loading. A basic rule is to have loading above 0.500 (Hair et al. 2017).

4.2.1: Second-Order Factor Analysis for TPPP Cost Performance

Table 4 and Figure 2 shows the measurement model, where all the items are presented related to their specific constructs with factor loading, after which some items were dropped from initial model due to low factor loading.

Table 4: Construct reliability and validity: Final Model

S/NO	Construct	CODE	Factor Loading	Cronbach Alpha	Composite Reliability	Average Variance Extracted (AVE)
A	Tariff Risk	TARF01 TARF02	0.863 0.578	0.550	0.711	0.591
B	Economic and Financial Risk	ECOFIN01 ECOFIN03	0.682 0.772	0.721	0.801	0.642
C	Legal Risk	LGL01 LGL03	0.757 0.838	0.760	0.778	0.637
D	Cooperation with public and private Risk	CPP05	1.000	1.000	1.000	1.000
E	Political Risk	POL01 POL05 POL07	0.704 0.681 0.629	0.694	0.746	0.654
F	Construction Risk	CONST05	1.000	1.000	1.000	1.000
G	Technology Risk	TECH02 TECH03	0.677 0.813	0.740	0.789	0.628
H	Operation Risk	OPR03	1.000	1.000	1.000	1.000
I	Nature/Environmental Risk	NANEV01 NANEV02	0.955 0.524	0.801	0.879	0.720
J	TPPP Project Performance (Cost)	COST	1.000	1.000	1.000	1.000

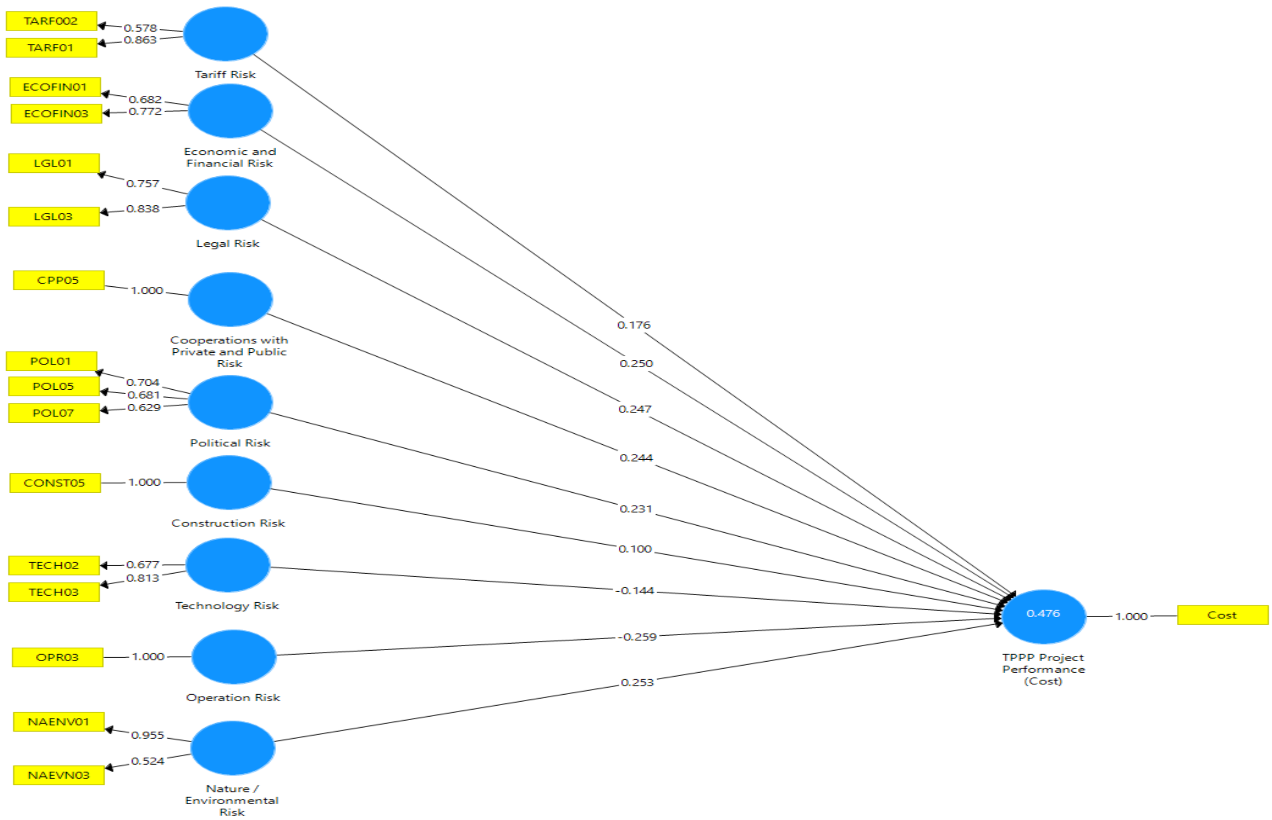


Figure 2: Final Model for TPPP Cost Performance

4.3: Discriminant Validity for TPPP Cost Performance

The discriminant validity is necessary for the construct validity of the outer model. It is essential to be tested before examining the hypothesis through path analysis. It shows the extent to which items differs between constructs. Fornell & Larcker (1981) suggests that an AVE score of 0.500 or higher is considered adequate in a given model, which has been achieved and as depicted in Table 5.

Table 5: Fornell–Larcker Criterion Test for TPPP Cost Performance

Construct	Construction Risk	Cooperation with Public and Private Risk	Economic and Financial Risk	Legal Risk	Nature/ Environmental Risk	Operation Risk	Political Risk	TPPP Project Performance (Cost)	Tariff Risk	Technology Risk
Construction Risks	**1.000**									
Cooperation with Public and Private Risk	0.027	**1.000**								
Economic and Financial Risks	0.001	0.073	**0.801**							
Legal Risks	-0.322	-0.145	0.031	**0.798**						
Natural/Environmental Risks	-0.041	-0.028	0.049	0.117	**0.849**					
Operation Risks	0.13	-0.284	0.252	-.085	0.064	**1.000**				
Political Risks	-0.209	0.286	0.039	0.084	-0.014	-0.118	**0.809**			
TPPP Project Performance Cost	-0.087	0.395	0.231	0.253	0.217	-0.274	0.369	**1.000**		
Tariff Risk	-0.08	-0.016	-0.051	-.016	-0.196	0.192	0.149	0.107	**0.769**	
Technology Risk	0.125	-0.251	-0.058	0.016	0.076	0.164	0.039	-0.259	-0.13	**0.792**

4.4: Cross Loading for TPPP Cost Performance

This shows various items as to identify those that have higher loadings on the same construct and those that load highly on multiple constructs. Table 6 shows the content validity of the measurements used which was explained in two ways. Firstly, there are high loading in the items on their respective constructs when related to other constructs. Secondly, it's the loading of the items were significantly loading on their respective constructs affirming the content validity of the measure used in this research (Adeleke et al., 2016; Taofeeq et al., 2020; Chow and Chan, 2008).

4.5: Evaluation of the Inner Structural Model: Relationship between the Risk Factors and TPPP Cost Performance

In PLS method, Structural Model and hypothesis were tested by computing path coefficients (β). After confirming that the measurement model was valid and reliable. The next step was to measure the Inner Structural Model outcomes. This included the relationships between the constructs, Path coefficient (β value) and T-statistic value, Effect size (f^2), and Goodness-of-Fit (GOF) index are the key standards for evaluating the inner structural model, as adopted by (Sarstedt et al., 2014).

By using Estimation of Path Coefficients (β) and T-statistics. The path coefficients in the PLS and the standardized β coefficient in the regression analysis were similar. To examine the hypotheses, the T-Statistics was utilized to assess each hypothesis, regression coefficients and identify the degree of significance which is based on the magnitude of T value (Hair et al., 2010); if T-Value is greater than 1.96 for a particular relationship, then a hypothesis is accepted, or else the hypothesis should be rejected, and also the weight of path coefficient for each relationship should be significant (Sig. ≤ 0.05), (Adeleke et al., 2015). The bootstrapping procedure was used to evaluate the significance of the hypothesis, as adopted by (Sarstedt et al., 2014). To test the significance of the path coefficient and T-statistics values, a bootstrapping procedure using 5000 subsamples with no sign changes was carried out for this study as presented in Table 7. The t-values of the parameter indicate the strength of the relationship in the parameter represents; therefore, the higher the t-value, the stronger the relationship (Huang, Lin & Chuang, 2007).

Table 7 and Figure 3 show the standardised T- Statistics (t-value) and p-values, which revealed that most of the hypotheses were significant at $p < 0.05$. The direction of the arrows denotes the direction of the assumed relationships between variables.

As depicted in Table 7, eight out of the nine hypotheses are accepted at 5% significant level. The relationship of Tariff Risk factor to TPPP Project Cost Performance (CP) is not supported at the acceptable level of $p > 0.05$ and failed to meet the 0.05 threshold, while other hypothesis including, Construction Risk; Cooperation with Public and Private Risk; Economic and Financial Risk; Legal Risk; Nature/Environmental Risk; Operation Risk; Political Risk; and Technology Risk all have a positive relationship with TPPP Project (Cost) Performance and therefore were supported at the acceptable level of $p < 0.05$.

Table 6: Factor Analysis and Loading of the items: CROSS LOADING

Items	Construction Risk	Cooperation with Public and Private Risk	Economic and Financial Risk	Legal Risk	Nature/ Environmental Risk	Operation Risk	Political Risk	Tariff Risk	Technology Risk	TPPP Project Performance (Cost)
CONST05	**1.000**	0.027	0.001	-0.322	-0.041	0.13	-0.209	-0.018	0.125	-0.087
CPP05	0.027	**1.000**	0.073	0.073	-0.028	-0.284	0.286	-0.016	-0.251	0.395
ECOFIN01	0.154	0.003	**0.682**	-0.05	-0.041	0.277	-0.052	0.12	-0.086	0.156
ECOFIN03	-0.132	0.096	**0.772**	0.086	0.102	0.103	0.099	-0.174	-0.005	0.18
LGL01	-0.216	-0.148	-0.048	**0.757**	0.128	0.113	0.073	-0.044	0.069	0.183
LGL03	-0.293	-0.089	0.086	**0.834**	0.065	-0.219	0.063	0.013	-0.033	0.219
NAENV01	-0.078	-0.081	0.022	0.184	**0.955**	0.081	-0.05	-0.18	0.116	0.22
NAENV03	0.088	0.14	0.097	-0.147	**0.524**	-0.023	0.095	-0.122	-0.085	0.077
OPR03	0.13	-0.284	0.252	-0.085	0.064	**1.000**	-0.118	0.192	0.164	-0.274
POL01	-0.186	0.127	0.008	-0.036	-0.137	-0.140	**0.704**	0.134	0.016	0.242
POL05	-0.046	0.215	0.036	0.022	0.061	0.044	**0.681**	0.095	0.046	0.276
POL07	-0.100	0.236	0.035	0.202	0.041	-0.168	**0.629**	0.069	-0.163	0.22
TARF002	0.162	0.074	-0.144	0.008	-0.127	0.118	-0.059	**0.578**	-0.043	0.059
TARF001	-0.122	-0.064	0.026	-0.025	-0.161	0.162	0.218	**0.863**	-0.132	0.095
TECH02	0.098	-0.267	-0.079	0.129	0.108	-0.010	0.049	-0.09	**0.677**	-0.17
TECH03	0.09	-0.127	-0.016	-0.08	0.016	0.229	-0.091	-0.104	**0.813**	-0.215
COST	-0.087	0.395	0.231	0.253	0.217	-0.274	0.369	0.107	-0.259	**1**

Table7: Path coefficient and T-statistics.

H1	Construct	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T-Statistics (IO/STDEVI)	P Values	Remark
H1a	Construction Risk --> TPPP Project Performance (Cost)	0.298	0.302	0.088	3.358	0.001	Supported
H1b	Cooperation with Public and Private Risk --> TPPP Project Performance (Cost)	0.244	0.224	0.092	2.646	0.008	Supported
H1c	Economic and Financial Risk --> TPPP Project Performance (Cost)	0.250	0.25	0.087	2.865	0.003	Supported
H1d	Legal Risk --> TPPP Project Performance (Cost)	0.247	0.245	0.096	2.563	0.011	Supported
H1e	Nature/Environmental Risk --> TPPP Project Performance (Cost)	0.253	0.231	0.123	2.046	0.019	Supported
H1f	Operation Risk --> TPPP Project Performance (Cost)	0.239	0.259	0.091	2.854	0.004	Supported
H1g	Political Risk --> TPPP Project Performance (Cost)	0.231	0.255	0.078	2.960	0.002	Supported
H1h	Tariff Risk --> TPPP Project Performance (Cost)	0.176	0.143	0.099	1.783	0.075	Not-supported
H1i	Technology Risk --> TPPP Project Performance (Cost)	-0.144	-0.159	0.084	2.311	0.021	Supported

Notes: β = Original Sample, M = Sample Mean, SD = Standard Deviation, t = T Statistics, p = P Values, CI = Confidence Interval, * Significant at $p < 0.05$ (***$p < 0.01$ at t-value = 2.58, **$p < 0.05$ at t-value = 1.96)

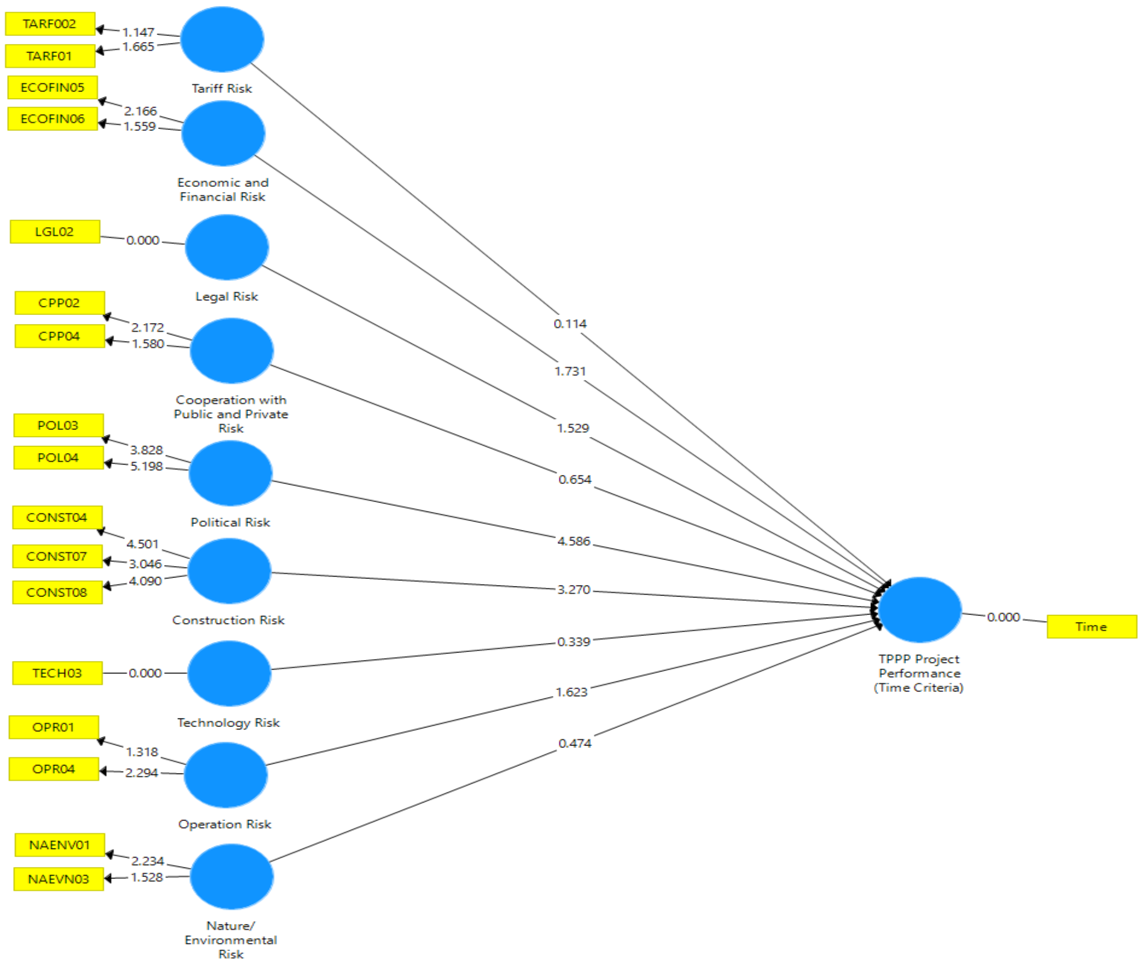


Figure 3: Path Model Bootstrapping for TPPP Cost Performance

4.6: Measuring the Impact of Risk Factors (Effect Size (f^2)) on TPPP Cost Performance

The f^2 is the degree of the impact of each exogenous latent construct on the endogenous latent construct. When an independent construct is deleted from the path model, it changes the value of the coefficient of determination (R^2) and defines whether the removed latent exogenous construct has a significant influence on the value of the latent endogenous construct.

As for size effect, Cohen (1988) suggested that the criteria of effect size when less than 0.02 = Small, <0.15= Weak, >0.15 = Moderate, >0.35 = Strong).

Hence, according to Cohen (1988) recommendation, the f^2 of five exogenous latent constructs (Construction Risk, Cooperation with Public and Private Risk, Legal Risk, Operation Risk, and Technology Risk) had a Strong effect on TPPP Project Cost performance, while One exogenous latent construct (Political Risks) had Moderate effect on TPPP Project Cost Performance and three other exogenous latent constructs (Economic and Financial Risks, Natural/Environmental Risks, and Tariff Risk) had a Weak effect on TPPP Project Cost Performance.

Furthermore, only the five independent latent constructs in this study participated relatively to the greater R 2 value (48.9%) in the dependent variable.

Table 8: Impact of Costs on Risk factors

Exogenous Latent Variables	Effect Size f2	Total Effect
Construction Risks	0.450	Strong
Cooperation with Public and Private Risk	0.410	Strong
Economic and Financial Risks	0.106	Weak
Legal Risks	0.590	Strong
Natural/Environmental Risks	0.114	Weak
Operation Risks	0.360	Strong
Political Risks	0.160	Moderate
Tariff Risk	0.050	Weak
Technology Risk	0.350	Strong

Source: (Research findings, 2022)

4.7: Evaluation Structural Model of TPPP Cost Performance

Goodness-of-Fit (GOF) is applied as an index for the complete model fit to verify that the model sufficiently explains the empirical data (Tenenhaus, 2005). The GOF values lie between 0 and 1, where values of 0.10 (small), 0.25 (medium), and 0.36 (large) indicate the global validation of the path model. A good model fit shows that a model is parsimonious and plausible (Henseler, Hubona, and Ray, 2016). The GOF was calculated by using the geometric mean value of the average communality (AVE values) and the average R^2 value(s), and the GOF of the model is calculated by Equation (1) (Tenenhaus, 2005).

$$\text{GOF} = \sqrt{\text{Average } R^2 * \text{Average communality}} \quad (1)$$

From Table 9, It was calculated that the GOF index for this study model was measured as 0.626, which shows that empirical data fits the model satisfactory and has substantial predictive power in comparison with baseline values.

Table 58 : Goodness of Fit Index

CONSTRUCT	AVE	R2
Construction Risk	1.000	
Cooperation with Public and Private Risk	1.000	
Economic and Financial Risk	0.642	
Legal Risk	0.637	
Tariff Risk	0.591	
Nature/Environmental Risk	0.720	
Operation Risk	1.000	
Political Risk	0.654	
Technology Risk	1.000	
TPPP Project Performance (Cost)	1.000	
AVERAGE VALUE	0.824	0.476
AVE x R^2	0.392	
GOF = $\sqrt{(\text{AVE X } R^2)}$	**0.626**	

Source: Research findings 2022

4.8: The Standardized Root Mean Square Residual (SRMR)

The SRMR is an index of the average of standardized residuals between the observed and the hypothesized covariance matrices (Chen, 2007). The SRMR is a measure of estimated model fit. When SRMR = <0.08, then the study model has a good fit (Hu & Bentler, 1998), with a lower SRMR being a better fit. Table 10 shows that this study model's SRMR was 0.056, which revealed that this study model had a good fit, whereas the Chi-Square was equal to 96.486 and NFI equal to 0.678 was also measured.

Table 10: Model fit Summary for TPPP Cost Performance

Estimated Model	
SRMR	0.056
d_ULS	0.962
d_G	0.263
Chi-SqUare	94.486
NFI	0.678

4.9 DISCUSSION OF RESULTS

From the relationship between the risk factors and TPPP cost Performance. Table 3 shows, the path between all nine exogenous latent constructs with an endogenous latent construct (Cost) were shown in regards their relationship and statistically significant, thus accepting some of the hypotheses proposed in this study.

The relationship of Tariff Risk factor to TPPP Project Cost Performance (CP) was not supported at the acceptable level of $p > 0.05$ and failed to meet the 0.05 threshold, while other hypothesis including, Construction Risk; Cooperation with Public and Private Risk; Economic and Financial Risk; Legal Risk; Nature/Environmental Risk; Operation Risk; Political Risk; and Technology Risk all have a positive relationship with TPPP Project (Cost) Performance and therefore were supported at the acceptable level of $p < 0.05$.

This was in line with the findings of the study by Luo et al., (2015) performed in Singapore. Detailed understanding of the project scope, plan, proper monitoring, and implementation substantially assists in the effective cost management in TPPP construction projects and hence improves the chance of better project without cost overrun and successful project completion.

Although the research of Tan and Ghazali (2011) was on performance of construction projects generally, it was documented that construction, technology and operation risk as related to local contractor experience is the most important risk factor in Singapore which is in agreement with this research outcome. This means that the possibility of delivering a project within a budget in Nigeria is largely dependent on the management capability of the foreign contractor/investors. It could be deduced that project failures in terms of cost overrun in Nigeria is largely due to deficient contractor's management skills.

In evaluating the influence of risk factors on TPPP Cost Performance. From Table 8, The results indicate that five exogenous latent constructs (Construction Risk, Cooperation with Public and Private Risk, Legal Risk, Operation Risk, and Technology Risk) had a Strong effect on TPPP Project Cost performance, while One exogenous latent construct (Political Risks) had Moderate effect on TPPP Project Cost Performance and three other exogenous latent constructs (Economic and Financial Risks, Natural/Environmental Risks, and Tariff Risk) had a Weak effect on TPPP Project Cost Performance. This is also in line with the study of Lawrence (2015) who found that Construction risk, Cooperation with Public and Private Risk, Legal Risk, Operation Risk, and Technology Risk had an impact on PPP cost performance. Roque & Carvalho (2013) investigated the impact of risk factors on building project performance in the same setting. Construction risk, Legal Risk, and Technology Risk has a considerable significant impact on TPPP cost Performance, according to the findings of their study.

5.0 CONCLUSIONS

In assessing the influence of risk factors on transnational public private Partnership performance in, in a view to help practitioners, stakeholders, and policy makers adequately understand and prepare for the possible risks to be encountered in TPPP infrastructure project performance. Partial Least Square-Structural Equation Modelling (PLS-SEM) was used in establishing the relationship between the risk factors and TPPP performance criteria in construction projects and determining the impact of risk factors on TPPP performance criteria in construction projects.

On relationship between the risk factors and TPPP cost Performance, the study concludes that the relationship between Tariff Risk factor and TPPP Project Cost Performance (CP) is not significantly supported, while risk factors including, Construction Risk; Cooperation with Public and Private Risk; Economic and Financial Risk; Legal Risk; Nature/Environmental Risk; Operation Risk; Political Risk; and Technology Risk have a positive relationship with TPPP Project (Cost) Performance. The study further indicates that five exogenous latent constructs (Construction Risk, Cooperation with Public and Private Risk, Legal Risk, Operation Risk, and Technology Risk) had a Strong effect on TPPP Project Cost performance, while One exogenous latent construct (Political Risks) had Moderate effect on TPPP Project Cost Performance and three other exogenous latent constructs (Economic and Financial Risks, Natural/Environmental Risks, and Tariff Risk) had a Weak effect on TPPP Project Cost Performance.

REFERENCE

Akintoye, A., Beck, W., Hardcastle, C., (2008). Public-Private Partnerships: Managing Risks and Opportunities. *Wiley-Blackwell, Hoboken, NJ.*

Abdul-Aziz, A. (2012) 'Control mechanisms exercised in Malaysian housing public-private partnership', *Construction Management and Economics, 30*(1), 37-55.

Babatunde. S.O. (2015). *"Developing Public Private Partnership Strategy for Infrastructure Delivery in Nigeria".* University of Northumbria at Newcastle. Doctor of Philosophy. (Unpublished)

Babatunde, S.O., Perera, S., Zhou, L. & Udeaja, C. (2015). Barriers to public private partnership (PPP) projects in developing countries: a case of Nigeria, Engineering, Construction and Architectural Management (ECAM) 22(6). 669-691.

Bing, L., Akintoye, A., Edwards, P. J., and Hardcastle, C. (2005). "The Allocation of Risk in PPP/PFI Construction Projects in the UK." *International Journal of Project Management*, *23*(1), 25–35.

Chan, A. P., Lam, P. T., Chan, D. W., Cheung, E., and Ke, Y. (2009). "Potential Obstacles to Successful Implementation of Public-Private Partnerships in Beijing and the Hong Kong Special Administrative Region." *Journal of Management. Engineering*. *26*:1(30), 30–40.

Chan, D. M. W.& Chan, J. H. L. (2013). Developing a Performance Measurement Index (PMI) for Target Cost Contracts in Construction: A Delphi study. *Construction Law Journal (28*)8, 590 – 613.

Chang, S.C., Chen, S.S., Lai, J.H., (2008). The Effect Of Alliance Experience and Intellectual Capital on the Value Creation of International Strategic Alliances. *Omega 36* (2), 298–316.

Chou, J. S., and Pramudawardhani, D. (2015). "Cross-country Comparisons of Key Drivers, Critical Success Factors and Risk Allocation for Public-private Partnership Projects." *International Journal of Project Management*. *33*(5), 1136–1150.

Huasheng, Z. (2016). "Afghanistan and China's New Neighborhood Diplomacy." *International. Affairs, 92*(4), 891–908.

Ke, Y., Wang, S., and Chan, A. P. C. (2010). "Risk Allocation in Public-Private Partnership Infrastructure Projects: Comparative Study." *Journal of Infrastructures System*. 343–351.

Li, B., Akintoye, A., Edwards, P.J., Hardcastle, C., (2005). "Critical Success Factors for PPP/PFI Projects in the UK Construction Industry". *Construction Management and Economics*, *23*(*5*), 459-471

Ng, S. T., Wong, Y. M. W., and Wong, J. M. W. (2010). "A Structural Equation Model of Feasibility Evaluation and Project Success for Public– Private Partnerships in Hong Kong." *IEEE Transp. Eng. Management*, *57*(2), 310–322.

Oboirien, M. O (2019). *Modelling Cost and Time Performance of Public Building Projects in a Terror Impacted Area of Nigeria*. Department of Construction Economics & Management. (PhD Thesis: Published). University of Cape Town.

Olanrewaju OI, Kineber AF, Chileshe N, Edwards DJ. (2022). Modelling the relationship between Building Information Modelling (BIM) Implementation Barriers, usage and Awareness on Building Project Lifecycle. *Build Environmental Journal*. 207:108556.

Omran, A., AbdalRahman, S. & Pakir, A. K. (2012a). Project Performance in Sudan Construction Industry: A Case Study. *Academic Research Journals (India) (1)*1, 55 – 78.

Omran, A., AbdulBagei, M. A., & Gebril, A. O. (2012b). An Evaluation of the Critical Success Factors for Construction Projects in Libya. *Journal of Economic Behaviour (2*). 17 – 25

Okwilagwe. O. O. (2017). "*Collaboration Processes in Partnership Working: Local Regeneration in Nigeria".* Bournemouth University. Doctor of Philosophy (Unpublished)

Osei-Kyei, R., Chan, A.P.C., (2015). Review of Studies on the Critical Success Factors for Public– Private Partnership (PPP) Projects From 1990 To 2013. *International Journal of Project Management 33* (6), 1335–1346.

PMBOK Guide, (2004). A Guide to the Project Management Body of Knowledge, Third Edition, *Project Management Institute, Four Campus Boulevard, Newtown Square, PA* 109733299 USA.

Rebeiz, K. S. (2012). "Public-Private Partnership Risk Factors in Emerging Countries: BOOT Illustrative Case Study." *Journal of Management Engineering*" 421–428.

Scandizzo, S. (2007) Public private partnerships and the infrastructure challenge in Latin America-Emerging markets forum [Online]. Available at:http://www.emergingmarkets forum.org/wp content/uploads/pdf/2007%20EMF%20 Uruguay%20Stafania_Scandizzo .pdf (Accessed: 11August 2022).

Siyanbola. T. (2018). *Evaluating the Risk Factors in Transnational Public Private Partnership Project. (*MSc Thesis Project). Ahmadu Bello University. (Unpublished).

Evaluating the Level of Adoption of Total Quality Management (TQM) Practices in Quantity Surveying Firms (QSFs) in Kaduna State, Nigeria

Kure, B. A.[1a] Alumbugu, P. O.[1b] and Mohammed, Y. D.[1c]
[1]Department of Quantity Surveying, Federal University of Technology, Minna, Nigeria
*Corresponding Author's Email: blessynkure@gmail.com

Abstract:

In construction, quality is defined by the client based on satisfaction with the product (completed work), processes, and/or services. However, several criticisms of lack of adherence to quality and standards have been directed at the Construction Industry in Nigeria. Organisations that are outcome-oriented are focused on improving products are likely to adopt Total Quality Management (TQM). This study aimed to evaluate the level of the eight latent variables of TQM practices adopted in Quantity Surveying Firms (QSFs) in Kaduna state, Nigeria. The Quantitative research design was adopted, and questionnaires were purposively distributed to the Principal and Senior Quantity Surveyors and Probationers of the firms. A sample size of 40 was established, and 28 responses representing 70%, were analysed. Descriptive statistics using SPSS version 21 was used to analyse the data collected. The results show that QSFs firms studied have high-level adoption for two latent TQM practices and a moderate level of adoption for the remaining six latent TQM practices. The study concluded that there was a moderate level of adoption of TQM practices by QSFs firms in Kaduna state, Nigeria. It thus provides QSFs and future researchers with a wider understanding of the practices that can inform the development of more effective TQM implementation. The study recommends that there is a need for further study of the challenges affecting the adoption of TQM practices by QSFs firms in Nigeria.

Keywords: Construction Firms, Quality Management, Total Quality Management.

Introduction

The concept of Total Quality Management (TQM) is becoming more widespread, which is a proactive management approach designed to build quality into the product and process (Reid and Sanders 2012). In recent years, more organisations are working towards TQM adoption (Jaeger and Adair 2016). In the global economy, many changes and transformational initiatives are being developed to increase effectiveness in organisations, TQM is one of those transformational initiatives and one of the most important management practices that have evolved (Haffar, Al-Karaghouli, and Ghoniem 2013). Previous research has viewed TQM as generic across industries and have classified firms as having the same size and financial strength (Schonberger,. 2017). In addition, almost all decisions on quality and related issues are focused on large organisations neglecting smaller firms (Chengiz 2018). Attempts should be made at assessing TQM based on the sizes of firms rather than generating generic results this is because TQM is important for small organisations as it is for large organisations (Haksever 2018).

The importance of TQM is seen in many spheres. A successful implementation of TQM helps the organization to focus on the needs of the market; facilitates to inspire for top quality performer in every sphere of activity; provides the framework necessary to achieve quality performance; helps to continuously examine all processes to remove non-productive activities and reduce waste(Attakora-amaniampong, Salakpi and Bonye 2016).

The concept of TQM is relatively new in Nigeria (Orumwese, 2014); thus, it is not progressing at the same rate as in developed countries. TQM focuses on improved customer satisfaction; however, there is no commitment to the cause among organizations in Nigeria (Chukwuka, 2016). Several criticisms of lack of adherence to quality and standards have been directed to the Construction Industry in Nigeria. Organisations that are outcome oriented and are focused on improving products are likely to adopt TQM (Olaleye, Ibrahim, Ibrahim, and Adogbo,. 2019). However, in spite of the benefits, a closer examination of literature shows that implementing TQM has not achieved results. According to Gambi, Gerolamo, and Carpinetti (2013) the problem is not with the TQM concept but the implementation of the practices.

TQM studies have been carried out in construction industry establishing the level of awareness (Shushma, 2014), the level of adoption of TQM practices (Chengiz 2018; Merih, 2016). Research have been carried out in the subject area in Nigeria, but not specifically focused on the Construction Industry. Chukwuka (2016) concluded that TQM has not yet attained a satisfactory level in Nigeria. studies by Ajayi *et al.* (2018) addressed the implementation of TQM in construction companies in Lagos, Nigerian organisations and concluded that there is a need to create awareness of the concept. Merih (2016) evaluated the TQM concept at a national level and recommends the need to assess the level of adoption of TQM practices. Therefore, this research is aimed at assessing the level of TQM practice in Quantity Surveying firms in Kaduna State, Nigeria.

Literature Review

In construction, quality is defined by the client based on satisfaction with the product (completed work), processes and/or services (Harinarian, Bornman, and Botha 2012). TQM concept properly implemented in construction has saved the construction industry from crisis that existed over a period of time (Shushma 2014). One of the strengths of quality improvement programmes is the ability to control the work process of management and employees, to recognize their problems, to trace the cause of the problems and to implement effective remedies (Nukic and Matotek 2014; Zhang, and Lui, 2017). Based on the review of literature, it is necessary to identify factors that contribute to the success of TQM implementation. These factors are considered critical to TQM implementation and are often stressed by TQM researchers (Makhdoomi, 2018; Flynn, and Saladin, 2016; Jaca, and Psomas 2015).

Most of the previous studies report that overall TQM practices have positively been related to productivity and manufacturing performance, quality performance, employee satisfaction/performance, innovation performance, customer satisfaction/results, competitive advantage market share, financial performance, and aggregate firm performance. However, some authors have found negative or insignificant results (Sadikoglu and Olcay, 2014; Sadikoglu, and Zehir 2012). Based on the literature reviewed by Sadikoglu and Olcay (2014) summarised eight TQM practices. These TQM practices are further discussed in the next section;

1. *Top management support (Leadership)*

Literature places emphasis on the vital role of top management in TQM implementation as a prerequisite for effective and successful implementation (Merih, 2016; Kantardjieva, 2015). This evidence is provided in previous research projects stressing that the role of leadership in TQM successful implementation. Top management takes the centre stage and must show strong evidence of commitment for the initiative to be successful (Valmohammadi, and Roshamir, 2015). Leadership must emphasize that quality initiatives are not just programmes of the year but a lifelong commitment by the firms to ensuring quality is attained in the products and processes of the firms (Talib, Rahman, and Quresh, 2012). Top management supervises, participates in the planning processes, ensures that policies are adhered to and properly implemented and provides support and motivation for the entire workforce.

2. *Strategic planning*

Strategic planning is a necessary foundation in the success of TQM, specifically, strategic plans on quality issues should be based on strength, weakness, opportunity and threats analysis (Talib, Rahman, and Quresh, 2012). Substantial attention has been paid to quality planning that are customer based by quality gurus though the attention they give to strategic planning vary. Planning is a vital stepping stone to accomplishing any task, TQM cannot be accomplished without strategic planning (Zu, Robbins, and Fredendall, 2010). One important factor that influences performance of any organisation is the strategic plan in place, which must be inclined towards quality. When strategic plans are not clearly defined, it is difficult to implement quality plans. According to (Gimenez-Espin, and Martínez-Costa, 2013), it is also important for strategic plans to be customer driven that is, customers must be at the centre of strategic plans of any organisation.

3. *Customer focus (Client satisfaction)*

Quality is defined by the customer; it is centred around the demands of the customers. Customer focus emphasizes on meeting and exceeding customer satisfaction as one of the most important features of TQM and that is also the focus of TQM definition (Talib, Rahman, and Quresh, 2012). In any production process, customer is an important element.

Any effective production process is aimed at meeting the needs and expectations of customers, which comes via, listening to customers and obtaining feedback for improvement (Migayawa and Yoshida, 2010). On a continuous basis, customer satisfaction must be stressed (Nasar, Yahaya and Shorun, 2015). The major aim of TQM implementation in any organisation must be to satisfy the needs of the customers and this must be emphasized in the mindset of the entire workforce. According to Goestec and Davis (2014), it is more expensive for organisations to gain a new customer than to keep a satisfied customer and further, easier to keep a customer that is pleased in the products (Migayawa and Yoshida, 2010).

4. *Measurement, Analysis, and Knowledge Management*

Measurement analysis is a detailed assessment of a measurement process that include research that is designed to identify variations that occur in the production process (Yasin and Alavi, 2007). similar to the production process that varies, the process of data collection and analysis also varies and can generate wrong results.

Measurement analysis checks the method used to conduct the test, the instrument used to conduct the test and the process of collecting the data to ensure the integrity of the data for analysis (Jaca, and Psomas, 2015). A careful assessment of the implication of errors is dome prior to decision making about the product or process. measurement analysis is vital for quality management and six sigma methodology.

5. *Workforce focus (Employee involvement)*

Workforce management can be defined as a systematic and planned activities to enhance an individual's performance. Success of TQM depends on people orientation that can be exhibited through initiatives such as team work, training and development (Goestec and Davis, 2014). Workforce management involves empowering the workforce to solve problems and make decisions at levels appropriate (Olaleye *et al*., 2019).This step is of great importance as workforce is closest to problems identified and are in the best position to take decisions that will solve the problem to improve production process. Workforce management begins with a personal commitment to quality. If the workforce accepts and commit to a quality course, they are more likely to be involved in quality tools and technique and apply the techniques in their daily activities (Arewa and Farell, 2015).

Workforce management include involvement of employees at all levels of the organisation, use of systems that motivate and promote workforce involvement, support from workforce should be encourage throughout the organisation, the level and effectiveness workforce should be assessed, teamwork should be encouraged between departments through effective workforce management to ensure effective TQM implementation (Zu, Robbins, and Fredendall, 2010).

6. *Operation focus (Process management)*

In any organisation, processes especially those that involve quality initiatives should include all functions and departments as the central focus of production (Arewa and Farell, 2015). A combination of process understanding, and process improvement is the lifeline of any organisation seeking to implement TQM. Process is what transform the input (i.e., actions, methods and operations) into output and should be error proof (Kim, Kumar and Kumar, 2012). For organisations that are quality focused, the customer should be at the centre of the process; that is, the output must satisfy or exceed the needs and expectations of their customers. At every stage of the process whether it is documented or not, several processes take place. Processes interact with each other throughout an organisation because the output from a process can be the basis of input to another process (Talib, Rahman, and Quresh, 2012).

7. *Supplier partnership*

Use of supplier rating system, selection of the supplier based on quality instead of price, clarity of specification provided by supplier, technical assistance to improve the quality and responsiveness of suppliers, involvement of the supplier in the project development process. Supplier quality management involves the "development of close partnerships, mutual trust, and parallel growth with suppliers" (Talib, Rahman, and Quresh, 2012). Effective supplier quality management is facilitated by long-term, cooperative relationships with as few suppliers as possible to obtain quality materials and/or services" (Mosadeghrad, 2015). Maintaining a small supplier base improves product quality and productivity of buyers by encouraging

8. *Project design*

Coordination among professionals involved in project design, analysis of client's requirement, clarity of project design, determination of quality standard, and design of the implementation system. The TQM practice, product/service design refers to the efforts to achieve clarity in respect to product and process design specifications prior to the offering of products / services to the market (Shan, Zhao and Hua, 2013). Engaging customers in the product/service design process and incorporating customers' expectations into new product development will enhance manufacturability, product features, and serviceability. Consideration of design for manufacturability will also lead to less manufacturing variances in the manufacturing process (Shan, Zhao and Hua, 2013). Hence, it is anticipated that the focus on product design will result in improved process management.

Research Methodology

Research Design

A quantitative research approach was chosen for this study. The target population of the study was all registered quantity surveying firms practicing in Kaduna State, Nigeria as obtained from the Nigerian Institute of Quantity Surveyors (NIQS) Directory. The sample size was 40 and data was collected using a purposive sampling strategy. The questionnaires were self-administered to the respondents. Respondents were informed that their participation in the survey was voluntary and that it was part of an academic investigation. All respondents were assured of the anonymity of their submitted surveys. Principal quantity surveyors, senior quantity surveyors, and probationers working in QSFs in Kaduna state were the respondents.

Data Collection

The questionnaire was designed to address the research objectives, determining the level of adoption of TQM practices in Quantity Surveying firms in Kaduna state, Nigeria. It has two sections, the first containing respondents' profiles, while the second has the eight reviewed TQM practices. The respondents indicated their views for fifty (50) range of statements regarding the presence of the eight TQM practices in their firms: top management support (leadership), strategic planning, customer focus (client satisfaction), measurement, analysis, and knowledge management, workforce focus (employee involvement), operation focus (process management), supplier partnership, and project design in their firms. The respondents use the five-point Likert scale (5=Very High, 4=High, 3=Moderately High 2=Low and 1= Very Low) to indicate their level of agreement to the statements.

Data analysis

The researchers gave 40 questionnaires to the participants and received 32 responses. There were 28 valid responses left out of 32 surveys gathered, equating to a 70 per cent effective response rate and representative of several QSFs within Kaduna state. The data from the questionnaire was transferred to an Excel spreadsheet so that it could be analysed more easily. The average of all the respondents' responses was used to create the overall company profile. The total firm profile was then translated to an Excel spreadsheet graph. Both perceived and preferred cultures' profiles were established.

The sample for this study was made up of the use of structured questionnaires employed for data collection to achieve the study's objectives. The collected data were analysed using the Mean Item Score (MIS). The decision rule adopted for the MIS analysis is summarised in Table 1

Table 1: Decision Rule for MIS Analysis

Scale	**Cut-off points**	Remarks/ Decision **Level of TQM Practices**
5	4.50 -5.00	Very high
4	3.50 -4.49	High
3	2.50 -3.49	Moderate
2	1.50 -2.49	Low
1	1.00 -1.49	Very low

Source: Adapted and modified from Agumba and Haupt, (2014)

Data Presentation and Analysis

Likert scale was used for each item measured 5 Points representing very high to 1point representing very low adoption of TQM practices. The data collected were analyzed using SPSS version 21 to tabulate the TQM practices.

Results

The Demographic Information on Respondents

This section presents and discusses the results of the demographic analysis of the participants in the field survey carried out during this study. A total of five (5) demographic variables were examined, as shown in Table 2.

Table 2: Result and Discussions on the demographic information on respondents

Demographic information	**Frequency**	**Percent**
Rank		
Principal partner	15	53.57
Senior Quantity surveyors	5	17.86
Junior Quantity surveyors	8	28.57
Total	28	100.00
Year of experience in the consultancy business	Frequency	Percent
1-5 years	5	17.90
6 – 10 years	8	28.60
11 – 15 years	3	10.70
16-20 years	3	10.70
> 20 years	9	32.10
Total	28	100.00
Respondent's years of experience in the firm	Frequency	Percent
1-5 years	13	46.43
6 – 10 years	3	10.71
11 – 15 years	5	17.86
> 20 years	7	25.00
Total	28	100.00
Respondents' awareness of organisation culture in the firm	Frequency	Percent
Yes	25	89.29
No	3	10.71
Total	28	100.0
Respondents' awareness of Total Quality Management in the firm	Frequency	Percent
Yes	28	100.00
Total	28	100.00

Sources: Authors field work (2022)

Table 2 presents the rank of respondents from the survey. The findings revealed that 54.0% of the respondents were principal partners, while 29.0% and 18.0% were junior quantity surveyors and senior quantity surveyors, respectively. Majority of the respondents (83%) were either principal quantity surveyors or senior quantity surveyors. Therefore, the respondents are adequately knowledgeable about organisational culture and total quality management practises in their various firms.

In addition, Table 2 shows results of years of experience of respondents in consultancy services. The results revealed that 18% of the respondents had less than 5 years of experience, 29% of respondents had 6–10 years of experience, 11% of the respondents had 11–15 years of experience, 11% of the respondents had 16–20 years of experience, and 32% had more than 20 years of experience in consultancy. In summary, about 82% of the respondents had 6years and above experience in consultancy services. This shows majority of the respondents have a vast level of experience in their field of quantity surveying. Furthermore, Table 2 revealed the findings on respondents' awareness of organisation culture in their firm. The findings show that 89.29% of the respondents opined yes, while 10.7 % of the respondents stated otherwise. Furthermore, the findings show that all the respondents (100%) are aware of total quality management practices in the quantity surveying firms.

Christabel and Vincent (2010) found that there are differences in the perceptions of professional quantity surveyors based on age, membership levels, and work experience. (Fan, Ho and Ng 2001) also pointed to the differences in perceptions of professional quantity surveyors due to differences in training. In research carried out by Lowe and Skitmore (2011) on the learning climate of chartered quantity surveying practices, it was found that as quantity surveyors rise in the hierarchy of an organisation, their perception of its ability to provide an appropriate learning environment increase. By implication, the perception of quantity surveyors' changes as their hierarchies increases in organisations. Hassan and Minden (2010) identified three hierarchies in quantity surveying firms, including directors, senior quantity surveyors, and junior quantity surveyors in Malaysian quantity surveying firms. The research also made explicit the expressed differences in perceptions of the hierarchies.

Level of adoption of TQM practices in Quantity surveying firms

The respondents indicated their views for a range of statements regarding the presence of TQM practices into eight; top management support (leadership), strategic planning, customer focus (client satisfaction), measurement, analysis, and knowledge management, workforce focus (employee involvement), operation focus (process management), supplier partnership, and project design in their companies as presented in Table 2. These findings are discussed in the next section.

1. *Top management support (Leadership)*

The results of the analysis from Table 2 revealed that all the six statements of TQM practices under the top management support (leadership) very high and high mean scores. The range of mean scores was between 4.38 and 3.50, which corresponds to high level of TQM practices adoption. While the average mean score was 3.92 indicating high level of Top management support adoption in QSFs.

2. *Strategic planning*

The Strategic planning components of TQM results indicated in Table 2 revealed that three out of the five statements have mean scores ranges between 3.5-4.0 which represent high level of adoption of TQM practices. While the remaining two mean scores were between 2.78-3.0 indicating moderate level of TQM practices adoption. But the average mean score was 3.3 indicating the respondent's perception was moderate level of Strategic planning adoption in QSFs.

3. *Customer focus (Client satisfaction)*

In the case of customer focus, two out of the six statements have mean scores of 3.89 and 4.0 indicating high level of adoption. But the remaining four statements under customer focus have mean scores ranges between 2.78-3.0 representing moderate level of their adoption. The findings also revealed average mean score was 3.3 representing moderate level of customers focus.

4. Measurement, Analysis, and Knowledge management

Table 3 indicated that four of seven statements of measurement, analysis, and knowledge management have mean scores ranges between3.77-4.23 representing high level adoption. While one statement has a mean score 4.5 establishing very level high adoption. The remaining two statements have mean scores were 2.65 and 3.00 representing moderate adoption. Finally, average mean score was 3.74 establishing high level of adoption of measurement, analysis, and knowledge management.

5. Workforce focus (Employee involvement)

The results of the analysis from Table 3 revealed that one out of the seven statements have a mean score 3.50 representing high level of adoption. While five have mean scores ranges between 2.5-3.33 representing moderate level of adoption. However, the average mean score was 2.83 showing moderate level of adoption of workforce focus practice.

6. Operation focus (Process management)

The results presented in Table 4.3 showed three out of the nine statements have mean scores ranges between 3.75-3.99 representing high level of adoption, another three have mean scores between 2.87-3.40 indicating moderate level of adoption. While the remaining three have mean scores range between 2.11-2.45 representing low level of adoption. The average mean score was 3.06 which established moderate adoption of Operation Focus (Process management) practices.

7. Supplier partnership

The results presented in Table 3 showed that four statements out five have mean scores range between 2.87-3.40 representing moderate level of adoption. While the remaining one has a mean score 2.47 indicating low level of adoption. The overall level of adoption of supplier partnerships practises was moderate level based on the average mean score value of 2.86.

8. Project design

Under project design as presented in Table 4.3, all the five statements have their mean scores range between 2.60- 3.47 representing moderate level of adoption. While the overall project design practises adoption was moderate level based on the average mean score value 3.02.

Table 3: Level of adoption of TQM practices in Quantity surveying firms

Top management support (leadership)	**Mean Score**	**Rank**
Top management hold meetings discusses and reviews quality related issues	4.38	1st
Top management establishes and sustains clear and visible customer-focused quality vision, values, and mission.	4.06	2nd
Top management encourages quality-related concepts and skills	3.98	3rd
Top management participates in quality management and improvement process	3.85	4th
Top management allocates adequate resources for quality Improvement	3.78	5th
Top management pursues long-term quality improvement process	3.50	6th
Overall level of Top management support (leadership)	**3.92**	
Strategic Planning	**Mean Score**	**Rank**
A mission statement which has been communicated throughout the company and is supported by employees	3.70	1st
A comprehensive structured planning process which regularly sets and reviews short and long-term goals	3.68	2nd
Incorporate supplier capabilities and needs of other stakeholders including the community when develops organisation's plans, policies, and objectives	3.50	3rd

Integrate continuous quality improvements into planning process	3.00	4th
Organisation's strategic plans and tactical plans are linked to quality values	2.78	5th
Overall level of Strategic Planning	**3.33**	
Customer Focus (Client satisfactions)	**Mean Score**	**Rank**
Take customer complaints as continuous improvement process	4.00	1st
Review customer complaints and take into consideration for product innovation	3.98	2nd
Provide mechanism for customer feedback	3.48	3rd
Customer focused practice and culture	2.90	4th
Conduct market study to collect suggestions for improving Product	2.85	5th
Conduct a customer satisfaction survey	2.60	6th
Overall level of Customer Focus (Client satisfactions)	**3.30**	
Measurement, Analysis and Knowledge Management	**Mean Score**	**Rank**
Data and information collection at all levels and in all parts of rganisation	4.50	1st
Analyse and review the data and information collected	4.23	2nd
Conduct organisational performance measure at a constant time interval period	4.10	3rd
Availability of key performance figures for analysis and decision making	3.95	4th
Performance review findings for continuous improvement and Innovation	3.77	5th
Implement organisational performance measurement system	3.00	6th
Benchmarking of other firms' product quality and procedures	2.65	7th
Overall level of Measurement, Analysis and Knowledge Management	**3.74**	
Workforce Focused (Employee involvement)	**Mean Score**	**Rank**
Employee performances are monitored and measured	3.50	1st
Encourage teamwork and problem solving among Employees	3.33	2nd
Provide training and development process for all Employees	2.98	3rd
Maintain a working environment that contributes to the health, safety, and well-being of all employees	2.85	4th
Instill quality culture on continuous improvement among Employees	2.78	5th
Promote compensation, recognition, and reward system among employees	2.50	6th
Measure employee satisfaction	1.85	7th
Overall level of Workforce Focused (Employee involvement)	**2.83**	
Operation Focus (Process management)	**Mean Score**	**Rank**
Practice daily operation work processes report system	3.99	1st
Develop a set of key work processes	3.80	2nd
Use of approaches or tools to improve process performance and reduce variability	3.75	3rd
Establish Key Performance Indicators (KPIs) for monitoring purpose	3.40	4th
Monitor and reviews on work processes performance	2.90	5th
Continuous improvement process	2.87	6th
Exercise two-way communication with suppliers	2.45	7th
Quality culture	2.30	8th
A well-prepared disaster and emergency preparedness system to ensure the continuity organisation's operations	2.11	9th
Overall level of Operation Focus (Process management)	**3.06**	
Supplier partnership	**Mean Score**	**Rank**
Use of supplier rating system	3.28	1st
Clarity of specification provided by supplier	3.08	2nd
Technical assistance to improve the quality and responsiveness of suppliers	2.89	3rd

Clarity of specification provided by supplier	2.58	4th
Involvement of the supplier in the project development process	2.47	5th
Overall level of Supplier partnership	**2.86**	
Project design	**Mean Score**	**Rank**
Coordination among professionals involved in project design	3.47	1st
Analysis of client's requirement	3.44	2nd
Design of the implementation system	2.88	3rd
Clarity of project design	2.75	4th
Determination of quality standard	2.60	5th
Overall level of Project design	**3.02**	

Source: Author's field survey (2022)

Discussion of Results

1. *Top management support (Leadership)*

The overall average mean score for Top management support was 3.92, which is for all the statements in the group. This means that all the responds agree that there was high level of adoption of Top management support practice in all the studied firms. The findings are line with the finding with the grand mean value 3.93 by (Olaleye *et al.* (2019). This is further collaborated other research findings by Ooi (2014) and Alidrisi and Mohamed (2012). Furthermore, the results established that, respondents agreed with following statements, that Top management hold meetings discusses and reviews quality related issues, leadership establishes and sustains clear and visible customer-focused quality vision, values and mission, and leadership encourages quality-related concepts and skills as they were ranked first, second and third, respectively.

The overall average mean score for Top management support was 3.92, which is for all the statements in the group. This means that all the responds agree that there was high level of adoption of Top management support practice in all the studied firms.

2. *Strategic planning*

The overall of the mean scores obtained for strategic planning was 3.33 which is for the five statements in the group. This indicates that all the respondents agree that the level of adoption of strategic planning practice was moderate. The finding is in line with the findings of (Frolova and Lapina, 2015; Mahmood, Qadeer, and Ahmad 2015). The study also established that these two statements were key; a mission statement which has been communicated throughout the company and is supported by employees and a comprehensive structured planning process which regularly sets and reviews short and long-term goals. Thus, they were ranked first and second.

3. *Customer focus (Client satisfaction)*

The overall mean score of customer focus (client satisfaction) obtained was 3.30, this implies that the firms agree that they moderately execute the activities that make up customer focus practice. This is similar to a finding by Olaleye *et al.* (2019) with the grand mean value 3.77. In addition, the findings confirm the findings by Mahmood, Qadeer, and Ahmad (2015) whose findings show a high degree of customer focus in the firms' studies. He further confirmed that customer focus is important for TQM implementation in Malaysia organisations.

The study established that these three priority statements; take customer complaints as continuous improvement process, review customer complaints and take into consideration for product innovation and provide mechanism for customer feedback. These were ranked first, second and third respectively.

4. *Measurement, Analysis, and Knowledge management*

The overall average mean score value 3.74 for measurement, analysis, and knowledge management practices implies all respondents agree to high level of adoption by all the firms studied. This is in agreement to a study by Olaleye *et al.* (2019) with an overall average of 3.95 for the 46 classifications of firms. The finding is also consistent with the findings of Jaca and Psomas (2015) whose findings show high level of measurement analysis practice in the firms studied. The respondents established by ranking the seven statements in the order of importance. Thus, the first, second and third were, data and information collection at all levels and in all parts of organisation, analyse and review the data and information collected, and conduct organisational performance measure at a constant time interval period, respectively.

5. *Workforce focus (Employee involvement)*

The average mean score was 2.83 which implies that all respondents agree to moderate level of adoption of Workforce Focused (Employee involvement) practises in the firms studied. The findings of this study agree with the conclusion by Kafetzopoulos, Gotzamani and Gkana (2015) whose findings concluded that Employee management also instils a better understanding of importance of the product quality in employees and makes them committed to the quality improvement. Furthermore, the findings of this study agree with the conclusion by Kim, Kumar and Kumar (2012), whose findings conclude that workforce involvement is important for TQM to be effectually realized, their findings indicate a high level of workforce commitment to quality in the firms studied.

6. *Operation focus (Process management)*

Operation Focus (Process management) practice has an overall average mean score value 3.06 implying that all the respondents agree that the level of adoption was moderate for all the firms studied. This finding is contrary to Olaleye *et al.* (2019) result with the average grand mean for the 46 classes of firms is 4.09. Furthermore, the findings by Kaluarachchi (2010) who studied Sri Lankan firms and Wu (2015) who studied Chinese firms.

7. *Supplier partnership*

The overall mean score 2.86 for Supplier partnerships practises implies that all the respondents agree that there was moderate level of adoption for the firms studied. The study also revealed the ranking of the first three statements out five as follows; use of supplier rating system, Clarity of specification provided by supplier, and technical assistance to improve the quality and responsiveness of suppliers, first, second and respectively.

8. *Project design*

The overall mean score was 3.02 indicating that all respondents agree that there was Moderate level of adoption of project design practises in the firms studied. The findings are consistent with the findings (Kafetzopoulos, Gotzamani and Gkana, 2015; Yusr, Mohd Mokhtar and Othman 2014)

In addition, the results established the importance of these statements: Coordination among professionals involved in project design, analysis of client's requirement, and Design of the implementation system as they were first, second and third, respectively.

Conclusions

This study is aimed at determining the level of TQM practices adoption in QSFs firms in Kaduna State, Nigerian. A total of eight TQM practices were evaluated for the QSFs firms. The study concludes that two out of the eight TQM practices; top management support, and measurement analysis and Knowledge (average mean scores 3.92 and 3.74) have high level adoption in the QSFs firms studied. While the remaining six practices; strategic planning, customer focus, workforce management, operation focus, supplier partnership and project design (average mean scores were 2.83-3.3) were moderately adopted in the firms studied.

The conclusion underscored need for TQM practices must start with top management and must demonstrate commitment towards the course, the central focus of quality is the customer thus firms must demonstrate their commitment to customer satisfaction, workforce execute the plans that firms. The implication of these findings is that the QSFs firms' level of adoption TQM practices is moderate therefore may difficult realise the full benefit of its implementation. Moreso, for TQM to be effective all the eight practices must have high level of adoption across the firms.

This article concludes by providing the Quantity Surveying firms with areas that require addressing, in order to improve TQM practices adoption in their firms to help ensure that the full benefit is achieved. This study has contributed to TQM practices levels of various QSFs firms in Nigeria. It thus provides QSFs and future researchers with a wider understanding of the practices that can inform the development of more effective TQM implementation. The study recommends that there is need for the further study of challenges affecting firms in the adoption and implementation of TQM.

Reference

Alidrisi, H. and Mohamed, S. (2012). Resource Allocation for Strategic Quality Management: A Goal Programming Approach. *International Journal of Quality and Reliability Management* 29(3): 265–83.

Arewa, O. A., and Farell, P. (2015). The Culture of Construction Organisation, the Epitome of Institunalised Corruption. *Construction economics and building* 15(3).

Attakora-amaniampong, Elvis, Andrews Salakpi, and Freda Bonye (2016). Total Quality Management and Its Impact on the Level of Customer Focus within Construction Project Management in Ghana Total Quality Management and Its Impact on the Level of Customer Focus within Construction Project Management in Ghana. (March).

Chengiz, H. (2018). Total Quality Management in the Small Business Environment. *Journal of Business finances.* 5(3): 77–91.

Chukwuka, A. Z. (2016). Organisational Approach to TQM in Nigeria. *International journal of business and financial initiative* 5(3): 89–9.

D.-Y. Kim, V. Kumar, and U. Kumar. (2012). Relationship between Qualitymanagement Practices and Innovation, *Journal ofOper- ations Management* 30(4): 295–315.

Fan, L., Ho, C. and Ng, V. (2001). A Study of Quantity Surveyors' Ethical Behaviour.' *Construction Management and Economics* 19: 19-36.

Flynn, B.B., and Saladin, A. (2016). Relevance of Baldrige Constructs in an Internaion Context; a Study of National Culture. *Journal of operations management* 24(5): 583–603.

Frolova, I. and Lapina, I. (2015). Integration of CSR Principles in Quality Management. *International Journal of Quality and Service Sciences,* 7(2/3): 260-273.

Gambi, L. N., M C Gerolamo, and Carpinetti, L. C. R. (2013). A Theoretical Model of the Relationship between Organisational Culture and Quality Management Techniques.' *Procedia. Social and Behavioural Sciences,* 81(1): 334-339.

Gimenez-Espin, Jiménez-Jiménez, D., and Martínez-Costa, M. (2013). Organizational Culture for Total Quality Management. *Total Quality Management and Business Excellence* 24(5–6).

Goestec D. L. and Davis, S. B. (2014). *Quality Management for Organisational Excellence. Introcuction to TQM 6th Edition. Pearson Practice Hall. USA.*

Haffar, M., Al-Karaghouli, W., and Ghoniem, A. (2013). The Mediating Effect of Individual Readiness for Change in the Relationship between Organisational Culture and TQM. *Total quality management,* 24(6): 693-706.

Haksever, C. T. (2018). Total Quality Management in the in Service and Commercial Industry. *Journal of quality success.* 9(1): 103–19.

Harinarian, N., Bornman, C. L. and Botha, M. (2012). Organisational Culture of the South African Construction Industry. *Engineering, property and development* 3(1): 22–43.

Jaca, C., and Psomas, E. (2015). Total Quality Management Practices and Performance Outcomes in Spanish Service Companies. *Total Quality Management and business excellence,* 26(9): 958-970.

Jaeger, M., and Adair, D. (2016). Perception of TQM Benefits, Practices and Obstacles. The Case Study of Project Managers and Quality Management Representatives in Kuwait. *The TQM journal, 28(2), 317-336* 28(2): 317–36.

Kafetzopoulos, D., Gotzamani, K. and Gkana, V. (2015). Relationship between Quality Management, Innovation and Competitiveness. Evidence from Greek Companies. *Journal of Manufacturing Technology Management,* 26(8): 1177–1200.

Kaluarachchi, K.A.S.P. (2010). Organizational Culture and Total Quality Management Practices: A Sri Lankan Case. *TQM Journal* 22(1): 41–55.

Kantardjieva, M. (2015). The Relationship between TQM and Strategic Management'. *journal of economics, business and management* 3(5): 538–49.

Mahmood, S., Qadeer, F. and Ahmad, A. (2015). The Role of Organizational Learning in Understanding Relationship between Total Quality Management and Organizational Performance. *Pakistan Journal of Commerce and Social Sciences* 9(1): 282–302.

Makhdoomi, U. M. (2018). Top Management Commitment and Diversity Challenge in the Telecom Sector. *Asian journal of managerial science* 7(1): 222–39.

Merih, A. (2016). Total Quality Management, Way to Achieve Excellence in Quality. *Strategic marketing communication* 5(2): 10–21.

Migayawa, Y., and Yoshida, M. (2010). TQM Practice of Japanese Owned Manufacturers in USA and China. *International journal of quality and reliability management* 27(7): 736–55.

Mosadeghrad, A.M. (2015). Developing and Validating a Total Quality Management Model for Healthcare Organizations. *The TQM Journal,* 27(5): 544-564.

Nasar, T., Yahaya, H. and Shorun R. (2015). TQM and Customer Satisfaction in Selected Service Industry in Ilorin, Nigeria. *International journal of sustainable development* 17(16).

Nukic, I. S., Matotek, J. (2014). Importance and Trends of Organisational Culture in Construction in Eastern Croatia. *Economic view 3* 7(1): 25–40.

Olaleye, Y. O., Ibrahim, Y.M., Ibrahim, A.D., and Adogbo, K.J. (2019). Assessing the Level of Adoption of TQM Practices in Nigerian Construction Firms In: Laryea, S. and Essah, E. (Eds), 5-7 August 2019, Accra, Ghana',. In *Procs West Africa Built Environment Research (WABER) Conference*, 116–27.

Ooi, K.B. (2014). TQM: A Facilitator to Enhance Knowledge Management? A Structural Analysis. *Expert Systems with Applications* 41(11): 5167-5179.

Orumwese, J. (2014). TQM Implementation in Nigerian Organisation. *International journal of finance and accounting* 3(1): 51–59.

Reid, R. D., and Sanders, N. R. (2012). *Operations Management an Integrated Approach (Fourth Ed.). United State of America: John Weiley and Sons.*

Sadikoglu, C. and Zehir, E. (2012) Relationships among Total Quality Management Practices: An Empirical Study in Turkish Industry. *International Journal ofPerformability Engineering* 8(6): 667–678.

Sadikoglu, Esin, and Hilal and Olcay. (2014). The Effects of Total Quality Management Practices on Performance and the Reasons of and the Barriers to TQM Practices in Turkey'. 2014.

Shan, S., Zhao, Q. and Hua, F. (2013). Impact of Quality Management Practices on the Knowledge Creation Process: The Chinese Aviation Firm Perspective'. . *Computers and Industrial Engineering* 64(1): 211–23.

Shushma, K. (2014). TQM a Need of the Construction Industry. *Construction opportunities and strategies* 5(2): 222–39.

T., Schronberger. (2017). Total Quality Management as a Forerunner of Academic Success. *Business horizon.* 1(1): 40.

T.O., Ajayi O.M. Akinsiku O.E and Salami. (2018). Implementation of Total Quality Management of Construction Companies in Lagos State, Nigeria. *JES* 2(1).

Talib, F., Rahman, Z. and Quresh, M. (2012). Analysis of Interaction among TQM Practices Using MBNQA. *An international journal* 18(4): 563–87.

Valmohammadi, C and Roshamir, S. (2015). The Guidelines of Improvement: Relations among Organizational Culture,TQM and Performance. *Int. J. Production Economics* 164(2015): 167–78.

Wu, S.J. (2015). The Impact of Quality Culture on Quality Management Practices and Performance in Chinese Manufacturing Firms. *International Journal of Quality* and *Reliability Management* 32(8): 799–814.

Yasin, M. M. and Alavi, J. (2007). The Effectiveness of Quality Improvement Initiative in Service Operational Context. *The TQM magazine* 19(4): 354–67.

Yusr, M.M., Mohd Mokhtar, S.S. and Othman, A.R. (2014). The Effect of TQM Practices on Technological Innovation Capabilities: Applying on Malaysian Manufacturing Sector. *International Journal for Quality Research* 8(2): 197–216.

Zhang, S.B., and Lui, A.M. (2017). TQM and Organisational Profile of Construction Companies in China. 2(1): 38–51.

Zu, X., Robbins, T.L., and Fredendall, L.D. (2010). Mapping the Critical Links between Organizational Culture and TQM/Six Sigma Practices. *Int. J. Prod. Econ.* 123(1): 86– 106.

SUB-THEME 6:
WELLBEING AND RESILIENCE OF THE BUILT ENVIRONMENT

Stabilization of clay-stonedust composite using calcium carbide residue and zeolite for road application

Alaka, O. E.[1a], Alhaji, M. M.[1b], Alhassan, M.[1c], Shehu, M.[1d], Mohammed, A. H.[1e], Eze, E. F.[1f]

[1]Department of Civil Engineering, Federal University of Technology, Minna, Niger State, Nigeria
[a]omolaralaka@gmail.com; [b]a.mustapha@futminna.edu.ng, [c]alhassankuta@futminna.edu.ng, [d]moh.shehu@futminna.edu.ng, [e]mohstructs@gmail.com, [f]e.emenike@futminna.edu.ng
Corresponding author: omolaralaka@gmail.com (+2348030730142)

Abstract

Clay soils are one of the major problem soils encountered during road construction activities. Construction of road on clay subgrade of the use of clay as road construction material are both discouraged due to peculiar behavior of clay soils. Studies have shown that the cause of early damage and failure of most highway pavements in the world today especially in Nigeria is poor subgrade soil conditions. This research paper is aimed at treating clay soils with stone dust and CCR admixed with zeolite to enhance its strength and durability. To achieve this purpose, index properties and preliminary test were carried out on the samples. Other test such as compaction characteristics, UCS, durability and micro-structural characteristics at varying composition of stone-dust admixed with CCR and zeolite were also conducted. It was revealed that the clay soil falls under clay of high plasticity (CH) based on USCS which cannot be used in its natural state for any component of flexible pavement structure. The Microstructural analysis of the clay using XRD and SEM revealed that the clay consists of both primary and secondary minerals including montmorillonite. The SEM showed the morphology of the compacted clay as flaky in nature with pore spaces. Maximum UCS of 2425kN/m^2 which satisfy a soil material to be used as base course material for highly trafficked road bases. This was achieved at 2% zeolite and 10% CCR at 10% stone dust replacement of 28 curing days. The optimal CCR required for effective stabilization of clay-stone dust lies between 5 to 10% with at 2% and 4% zeolite additions for 1, 7 and 28 curing days. The highest UCS value obtained for clay- stone dust stabilized with CCR and zeolite only increased by seven times the strength of the natural clay which has a highest UCS of 359kN/m^3.

***Keyword**: Calcium Carbide Residue (CCR), Clay, Road, Stabilization, Stone-dust and Zeolite*

Compressive Strength of Millet Husk Ash as Alternative to Silica Fume in Internally Cured High Performance Concrete

Onogwu, C. M.[a], Apeh, J. A.[b], Olawuyi, B. J.[c] and Okoh, B. O.[d]
[1]Department of Building, School of Environmental Technology,
Federal University of Technology, P.M.B 65, Minna, Nigeria
[a]xtianpepsy@gmail.com; [b]apehjoe@futminna.edu.ng; [c]babatunde@futminna.edu.ng; [d] oka2bless@gmail.com
Corresponding email: xtianpepsy@gmail.com

Abstract

Challenges of deterioration and premature failure of concrete structures made with normal concrete (NC) has led to the development of high-performance concrete (HPC) which is a low water-binder and very dense concrete. However, lack of adequate internal water for proper curing in HPC are noted to result in autogenous shrinkage and micro-cracking for which existing literature showed are often addressed by incorporating internal curing (IC) agents such as superabsorbent polymers (SAP) and pre-saturated lightweight aggregate (LWA). Also of note is that HPC production requires additional supplementary cementitious materials (SCM) especially Silica fume – a material not readily available in Sub-Saharan Africa like Nigeria. This study thereby is a report of attempt at utilizing Millet husk ash (MHA) as SCM in HPC as an alternative to Silica fume for the development of a sustainable built environment in the era of COVID-19. The HPCs were internally cured with presoaked pumice as LWA and SAP respectively with the view to establish the effectiveness of Nigeria supplementary cementitious material (MHA) and IC-agent (presoaked pumice) for production of HPC. This article presents results of 28th day compressive of C55/67 HPC mixtures for 100 mm concrete cubes having 7.5% silica fume content in comparison with MHA based HPC of varied (2.5%, 5%, 7.5%, 10% and 15%) MHA contents. The SAP and Presoaked pumice contents were maintained as 0.2% by weight of binder (b_{wob}) and 5% by weight of coarse aggregate (b_{woca}) and the cubes were subjected to curing in water by immersion for 28 days before testing.HPC mix with 2.5%MHA internally cured with 5% pre-soaked pumice and 0.2% SAP content gave the best performance having 28th day compressive strength of 53.58N/mm^2 and 55.62N/mm^2 respectively.

Keywords: Millet husk ash (MHA), Silica fume (SF), Superabsorbent polymers (SAP), Pre-soaked lightweight aggregate, and High-performance concrete (HPC).

1.0 INTRODUCTION

Concrete is a composite material made by mixing cement, water and aggregates (Neville, 2012; Mudashiru *et al*. 2021). The foundation of the material is cement which when mixed with water forms a paste that binds aggregates together thereby setting to form a hard material called concrete. The strength of concrete is commonly considered as the most valuable property because it usually gives an overall picture of the quality of concrete and it is the most vital element of structural design which is specified for compliance purpose (Olawuyi *et al*., 2020, Mudashiru *et al.*, 2021). Many materials are being added to concrete to improve its properties in both fresh and hardened state, but still serve the same purpose as cement and with good workability (Olawuyi *et al*., 2020).

Challenges associated with deterioration and premature failure of normal concrete (NC) structures has led to the development of high-performance concrete (HPC) which is a solution to normal concrete (NC) (Mudashiru *et al*. 2021).Nowadays, high performance concrete (HPC) is mostly used in the construction industries for constructing tunnels, bridges, tall buildings because of its high durability, high strength, low water: binder (W/B) ratio, high modulus of elasticity (Aïtcin, 2004 and Orosz, 2017).

With HPC, thinner structural members can be constructed thereby giving rise to an aesthetically appealing structure (Nduka *et al.* 2020). The construction of structural member using HPC will help to reduce the amount of steel to be used, reduce the entire structure pressure, and increase functional spaces in buildings. Hence, greater architectural freedom, nearly unlimited structural shapes, forms, and near free reinforcement bars which results to lower labour and cost can easily be achieved by architects and designers (Wang *et al*., 2015).

The amount of cement and supplementary cementitious materials (SCMs) added to the HPC mix usually cause an increase in temperature on addition of water and densification in the concrete area. The study of Savva *et al*. (2018) on direct relationship between ambient temperature and cementitious materials reveal that the grains of the cementitious materials are usually influenced by ambient temperature, hence fast reaction which obstruct uniform distribution of hydration products and makes the hydrated gel to be more porous. The incorporation of SCMs causes autogenous shrinkage, chemical shrinkage, and self-desiccation resulting from the combined effect of hydration and pozzolanic reaction and this has led to an increase in water demand in the concrete (Wu *et al.*, 2017).

One of the most effective and efficient way of providing solution to these challenges in concrete production is by using a curing method called internal curing (IC). IC method has been reported to be one of the most effective and efficient way of reducing risk associated with autogenous shrinkage since low permeability of HPC renders external curing not to be sufficient enough for water to penetrate into the concrete (Olawuyi *et al.*,2017, Mudashiru *et al*. 2021). Hence, the incorporation of IC agents which has the ability to absorb water and release it in to the system when the need arises.

Researches has been carried out on the use of different IC agents in HPC production with lightweight aggregate (LWA) and superabsorbent absorbent (SAP) being the most commonly used in literature (Mudashiru *et al*. 2021). Hence, this article will focus on performance assessment of MHA as alternative to SF in internally cured High performance concrete with the view to establish the effectiveness of Nigeria supplementary cementitious materials (MHA) and internal curing agent (pre-soaked pumice) in HPC production for the development of sustainable built environment in the era of COVID-19.

2.0 EXPERIMENTAL PROCEDURE

2.1 Materials

The materials used for this research are binders (PC, SF and MHA), fine aggregates (sand), coarse aggregate, super plasticizer, pumice, superabsorbent polymer (SAP) and water.

The PC for this study was Dangote brand (3X) of Portland cement (CEM 42.5N) whose properties conform to the requirements of NIS 444-1:2014 and BS EN 197-1: 2016. It was purchased from a cement store in Gidan-Kwano; Minna, Niger State.

The MHA which was used as (SCM) was obtained from the incineration of the husk using the locally fabricated incinerator available at the Concrete Laboratory of the Department of Building, Federal University of Technology (FUT), Minna, Niger State. The burning took place in an open air for about 24 hrs with a temperature just below 700^{o}c and then allows to cool before harvesting and milling with grinding machine. The milled MHA was sieved with 75µm in accordance to ASTM C430- 2014 before storing in an airtight polythene bag.

The SF used as the second SCM for this study was purchased from Purechem chemical company in Lagos.

The fine aggregate used for this research is natural sand with minimum particle size of 300 μm which is the required specification for HPC production (Shetty 2004, Neville, 2012, Nduka *et al*., 2020; Olawuyi *et al*., 2020). The physical characteristics of the sand (i.e., specific gravity (SG); fineness modulus (FM); coefficient of uniformity (C_u); coefficient of curvature (C_c); and dust content) were analysed using the sieve analysis.

SAP (labelled FLOSET 27CS) of ≤ 600 µm grain size produced in France by SNF Floerger was added at 0.2% by weight of binder (b_{wob}) as detailed in Olawuyi and Boshoff (2017) considering 12.5 g/g as the SAP absorption capacity conforming to the requirement of SAP specification for the production of HPC determined by tea-bag test result of Olawuyi *et al*., (2021). The SAP type used is a thermoset polymer specifically the covalently cross-linked polymers of acrylamide and acrylic acid obtained from bulk solution polymerization and neutralized by alkali hydroxide.

The pre-soaked Pumice used for this study was a porous igneous rock formed as a result of explosives volcanic eruptions which was later crushed and 12.5 mm maximum size was incorporated. The pumice was soaked in water for 24 hrs after which it was drained before use (Olawuyi *et al*., 2020).

Crushed granite stone which passed through 13.5 mm sieve size and retained on at least 9.5 mm sieve size was used as coarse aggregate in compliance with typical HPC mixes found in literature (Aitcin, 2004; Beushausen and Dehn, 2009; Neville, 2012; Olawuyi & Boshoff, 2018; Nduka *et al*., 2020;

Olawuyi *et al.*, 2021). The coarse aggregate was washed to remove dust impurities for less water demand by the mixture.

The water for the study was portable water from the tap behind the convocation Square of Federal University of Technology, Minna, Niger State in accordance with the specification of BS EN 1008 (2002) and was used for the mixing at 0.3 W/B (Ogunbayo *et al*, 2018).

A Sky 504 Mastergleniumpolycarboxylic ether (PCE) superplasticizer supplied by Armorsil Manufacturing Incorporation was used as the chemical admixture (superplasticizer) and was administered at 1.5% concentration by weight of binder (b_{wob}) in the typical HPC mixtures in accordance with manufacturers specification with conformity with cement ascertained as recommended in the work of Aitcin (1998) reported in Olawuyi (2021).

2.2 Methods

2.2.1 Properties of constituent materials

The oxide compositions of binders (MHA, SF & OPC) were conducted using X-ray Fluorescent (XRF) at the Laboratory of the National Geoscience Research Laboratory, Kaduna State. About 100g of these binders were packaged in sealed polythene bags and sent after the calcination, grinding and sieving for the determination of the oxide compositions in accordance with BS EN 196-6: 2016. The particle size distribution of the aggregate's samples (i.e., the sieved sand and granite stone) was determined by wet sieving while the specific gravity of the aggregate and binders were also determined in the Building Laboratory of FUT, Minna in accordance with EN 12390-7.

2.2.2 Production of HPC Specimen

In accordance with the work of Olawuyi *et al.*, 2021, mean target strength of C55/67 at 28 dayswas adopted as the mix design procedure for material proportioning for HPC production. Table 1 shows mix proportioning of the HPCs with 5% of pre-soaked pumice by weight of coarse aggregate (b_{woca}), and 0.2% SAP by weight of the binder.

Table 1: Mix proportioning of the HPC mixtures

Mix proportion	Materials (Kg/m^3)								
	PC	SF	MHA	F/Agg.	C/Agg	pumice	SAP	SP	water
With 5% pre-soaked pumice									
M0a	499.5	40.5		700	997.5	52.5		8.1	156
M1a	526.5		13.5	700	997.5	52.5		8.1	156
M2a	513		27	700	997.5	52.5		8.1	156
M3a	499.5		40.5	700	997.5	52.5		8.1	156
M4a	486		54	700	997.5	52.5		8.1	156
M5a	459		81	700	997.5	52.5		8.1	156
With 0.2% SAP									
M0b	499.5	40.5		700	1050		1.08	8.1	156
M1b	526.5		13.5	700	1050		10.8	8.1	156
M2b	513		27	700	1050		1.08	8.1	156
M3b	499.5		40.5	700	1050		1.08	8.1	156
M4b	486		54	700	1050		1.08	8.1	156
M5b	459		81	700	1050		1.08	8.1	156

NB: F/Agg = Fine Aggregate; C/Agg = Coarse Aggregate; SP = Superplasticizer; **M0**=92.5%PC+7.5%SF; **M1**=97.5%PC+2.5%MHA; M**2**=95%PC+5%MHA; **M3**=92.5%PC+7.5%MHA; **M4**=90%PC+10%MHA; **M5**=85%PC+15%MHA; **a**=5% pre-soaked pumice; **b**=0.2% SAP

The SAP contents 0.2%b_{wob}) was used for the SAP internally cured HPCs with additional water of 12.5 g/g provided for SAP absorption while 5% by weight of the coarse aggregate of the saturated pre-soaked pumice was measured and used for the Pumice internally cured HPCs. After 24 hours, the cast 100 mm cubes HPCs were de-moulded and cured by full immersion in water for 28days before testing for compressive strength.

2.2.3 Fresh and strength properties

The preparation and curing of HPC samples were made in accordance to BS EN standards (BS EN 12350 -1 & 5, 2000; 12390-1 & 2, 2000; 12390 - 3, 2002) for compressive strength. The compressive strength tests were performed on 36 samplesat 0.5 N/mm^2 rate of loading using 2000kN loading capacity ELE Compressive Strength Testing Machine with a model number AT-120-1.1.

3.0 RESULTS AND DISCUSSION

3.1 Physical and Chemical Properties

Table 2 present the result of XRF analysis of the binders (MHA, SF & PC) powder. The result shows that The MHA is a Class N Pozzolan having total useful oxides (SiO_2 + Al_2O_3 + Fe_2O_3) content of87.2 %, which is above 70% minimum limit as specified in ASTMC 618 (2012). The SF major oxide is SiO_2 (96.2 %) implying that it is a very strong and reactive Class F Pozzolan in accordance to ASTM C618. The total SiO_2+Al_2O_3+Fe_2O_3 for the SF (96.91 %) is above the 70% specified for the Class of Pozzolan in ASTM C618. The PC on the other hands major oxide is calcium oxide (CaO – 64.35 %). This conformsto oxides composition for CEM II Portland cement found in literature (Neville, 2012; Mehta & Monteiro, 2014).

Table 2: Oxide Composition of Binder Constituents

Oxides	MHA (%)	SF (%)	CEM II (%)
SiO_2	71.05	96.20	25.64
Al_2O_3	14.66	0.45	5.24
Fe_2O_3	1.49	0.26	7.15
CaO	1.55	0.05	64.35
MgO	0.73	0.03	0.41
SO_3	0.67	0.10	0.11
K_2O	5.21	0.02	0.05
Na_2O	1.16	0.02	0.31
M_2O_5	2.06	0.50	0.04
P_2O_5	1.19	0.4	0.03
LOI	2.10	1.02	0.00
SiO_2 + Al_2O_3 + Fe_2O_3	87.20	96.91	38.03

Figure 1 and Table 3 show the physical properties of the aggregate used for the study. From the result it reveals that the fine aggregate is in conformity to the medium sand classification of Shetty (2004) having a uniformity coefficient (C_u) of 2.39, coefficient of curvature (C_c) of 0.94 and fineness modulus (FM) of 2.88.

Table 3: Summary of sieve analysis of aggregates

Item	Sand	Granite	Pumice
D_{10}	360	10000	10000
D_{30}	540	11000	11000
D_{60}	860	13000	13000
C_u	2.39	1.3	1.3
C_c	0.94	0.93	0.93
FM	2.87		

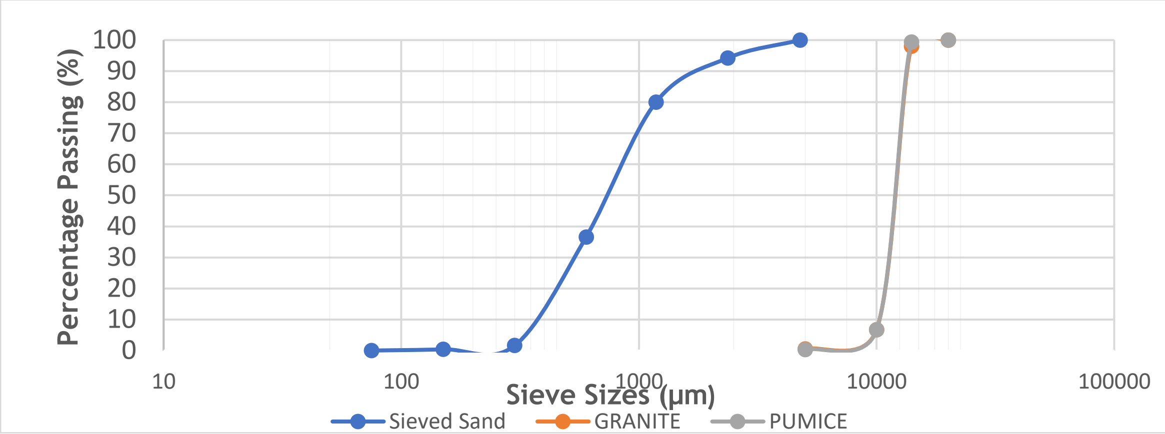


Figure 1: sieve analysis/particle size distribution of aggregates

Table 4 present the specific gravity of the constituent materials (PC, MHA, SF and aggregates). The results gave the values as 3.14, 2.63, 2.24, 2.85, 2.85 and 1.77 for PC, MHA, SF, sand, granite and pumice respectively. The values are inconformity with the previous reports found in literature (Neville, 2012).

Table 4: Specific Gravity of PC, MHA, CCW and aggregates

Materials	PC	MHA	SF	F/Agg.	Granite	Pumice
Specific gravity	3.14	2.63	2.24	2.85	2.85	1.77

3.2 Fresh and strength properties

Workability test for each of the HPC mixture with 5% pre-soaked pumice and 0.2% SAP was examined using slump flow test as described in BS EN (12350 - 5 - Part 1) before the production of the specimens. From figure 2 below, the slump flow value for the various HPCs with 5% of pre-soaked pumice are 490, 505, 520, 530, 545 and 560 mm while slump flow of HPCs with 0.2% of SAP are 510, 518, 525, 540, 555 and 570 mm. The slump flow increases as the percentage of MHA increase for both HPC containing 5% pre-soaked pumice and 0.2% of SAP. However, the slump flow values of the HPCs with 0.2% of SAP is higher when compared with that cured internally with 5% pre-soaked pumice. It was also observed that the slump flow values for all the HPC mixtures are within permissible value of 460-600 mm as the standard requirement for HPC production as specified by the code. This implies that irrespective of the IC-agents incorporated, the workability was within acceptable limit.

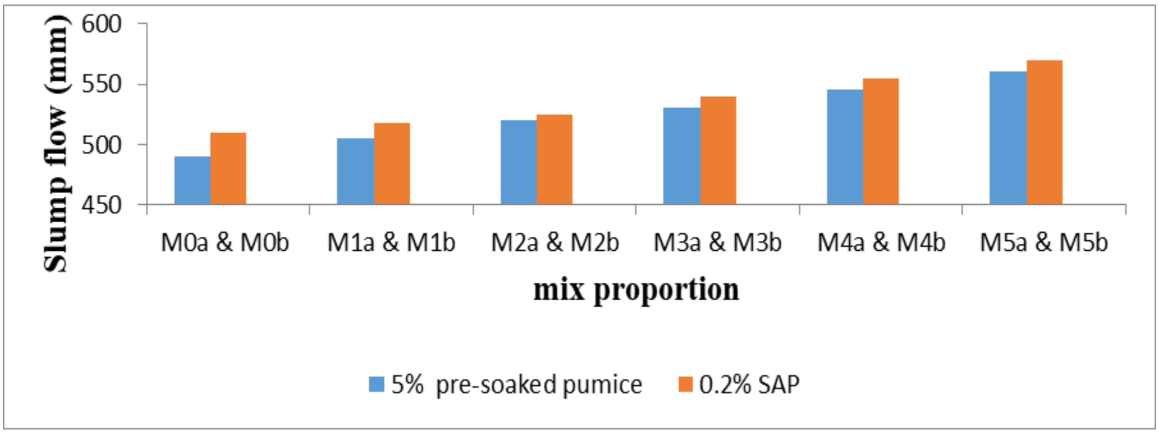


Figure 2: Workability of HPCs

M0=92.5%PC+7.5%SF; **M1**=97.5%PC+2.5%MHA; **M2=**95%PC+5%MHA; **M3**=92.5%PC+7.5%MHA; **M4**=90%PC+10%MHA; **M5**=85%PC+15%MHA**a=**5% pre-soaked pumice; **b**=0.2% SAP

Figure 3 present the compressive strength of the HPCs cured in water at 28days of age. The values obtained for all the HPCs with 5% pre-soaked pumice are; 58.62, 53.58, 52.04, 50.21, 47.73 and 45.90. While the HPCs with 0.2% SAP are 59.86, 55.62, 53.29, 52.70, 49.54 and 48.08. The result revealed that as the percentage of MHA increases, the value of compressive strength decease for both HPCs mix with 5% pre-soaked pumice and 0.2% SAP but HPCs mixes with 0.2% SAP was observed to have the highest value of compressive strength when compared with HPCs with 5% pre-soaked pumice at 28 days of curing. From the figure, it also shows that the HPC with 7.5%SF was the highest follow by 2.5%MHA, 5%MHA, 7.5%MHA, 10%MHA and 15%MHA as the least.

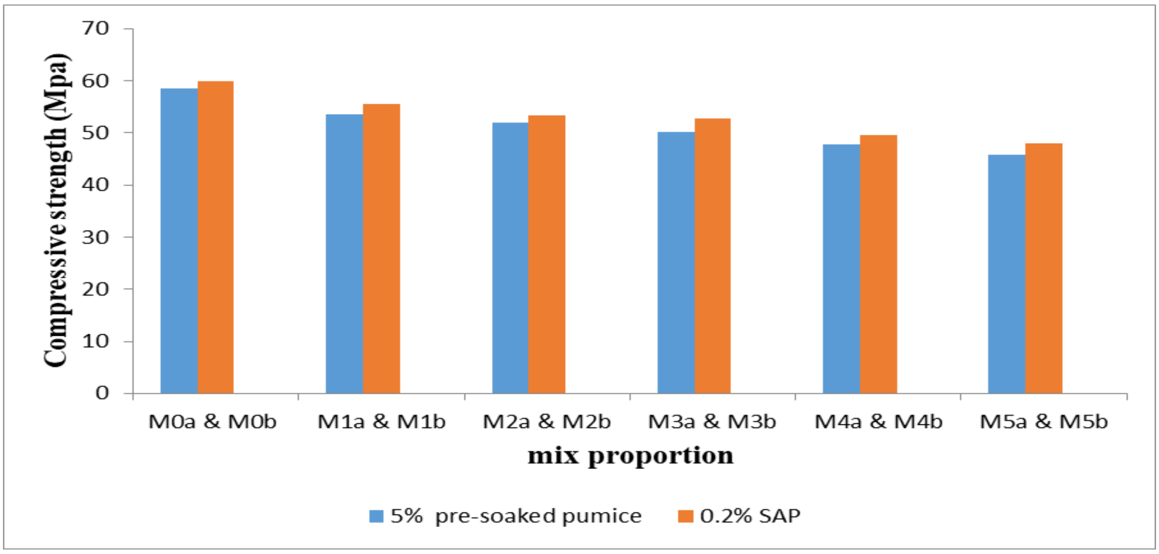


Figure 3: compressive strength of HPCs cured in water at 28 days
M0=92.5%PC+7.5%SF; **M1**=97.5%PC+2.5%MHA; **M2=**95%PC+5%MHA; **M3**=92.5%PC+7.5%MHA; **M4**=90%PC+10%MHA; **M5**=85%PC+15%MHA
a=5% pre-soaked pumice; **b**=0.2% SAP

4.0 CONCLUSION AND RECOMMENDATION

From the study, the following conclusion was deduced;

1. The SF and MHA used for the study were a good Class F and N Pozzolan with physical and chemical properties that conform to ASTM C618 specifications.
2. 2.5%MHA HPC has a closer value of compressive strength when compared with 7.5%SF HPC for both pre-soaked pumice and SAP internally cured HPC.
3. The compressive strength of HPCs internally cured with 0.2% SAP is more than the compressive strength of HPCs internally cured with 5% presoaked pumice.
4. The compressive strength of HPCs decrease as the MHA content increases for both 5% presoaked pumice and 0.2% SAP With 2.5%MHA having the highest value of compressive strength of 53.58 and 55.62 for 5% pre-soaked pumice and 0.2% SAP content respectively. Also, the compressive strength of HPC with 2.5%MHA internally cured with 0.2% SAP is higher than the strength of HPC with 2.5%MHA internally cured with 5% pre-soaked pumice.
5. MHA content of 2.5% and 5% pre-soaked pumice are recommended for use as Nigeria local SCM and IC-agent in HPC.

REFERENCE

Aïtcin, P. C. (2004). *High-Performance Concrete*. Taylor & Francis e-Library. *New York*.

British Standard Institution – BSI (2000) Cement – composition, specifications and conformity criteria for common cements, BS EN 197: Part 1, London.

BSI (2000) Testing of fresh concrete, BS EN 12350: Part 1, Sampling, London.

BSI (2000) Testing of fresh concrete, BS EN 12350: Part 5, Flow Table Test, London.

BSI (2000) Testing of hardened concrete, BS EN 12390: Part 1, shape, dimension and other requirement for specimens and mould, London.

BSI (2000) Testing of hardened concrete, BS EN 12390: Part 2, making and curing specimen for strength tests, London.

BSI (2002) Testing of hardened concrete, BS EN 12390: Part 3, compressive strength test specimens, London.

BSI (2004) Eurocode 2 – Design of concrete structures – Part 1-1: General rules and rules for buildings, Londo.

Mudashiru, S. A., Olawuyi, B. J., Ayegbokiki, S. T., Ndayako, S. K. (2021). Influence of magnesium sulphate on compressive strength of rice husk ash based high performance concrete in: *Proceedings of the 3rd School of Environmental Technology International Conference on Sustainable and House Management*, 271-278.

Nduka, D. O., Olawuyi, B. J., Mosaku, T. O., Joshua, O. (2020). Influence of superabsorbent polymers on properties of high-performance concrete with active supplementary cementitious materials of Nigeria. In: Rilem conference on the application of superabsorbent polymers and other new admixtures, W. P. Boshoff et al. (Eds.): SAP 2019, RILEM Bookseries 24, pp. 65–74, 2020. https://doi.org/10.1007/978-3-030-33342-38.

Neville, A. M. (2012), Properties of concrete (Fifth ed.), England: Pearson Educational Limited.

Olawuyi, B. j., Babafemi, A. J., & Boshoff, W. P. (2021). Early-age and long-term development of high-performance concrete with SAP: Building and Materials. 267 (2021) 121798. www.elsevier.com/locate/conbuildmat.

Orosz, K. (2017). Early Age Autogenous Deformation and Cracking of Cementitious Materials - Implications on Strengthening of Concrete. A Doctoral Dissertation submitted to Lulea Tekniska University, Lulea, Sweden.

Savva, P., Nicolaides, D., & Petrou, M. F. (2018). Internal curing for mitigating high-temperature concreting effects. *Construction and Building Materials*, ***179***: 598-604

Shetty, M. S. (2004), Concrete technology - theory and practice, New Delhi, India: S. Chand and Company Limited Technology (pp. 219 - 228)., Midrand, South Africa: *Cement and Concrete Institute.*, 219-228.

Wang, D., Shi, C., Wu, Z., Xiao, J., Huang, Z., & Fang, Z. (2015). A review on ultra-high-performance concrete: Part II. Hydration, microstructure and properties. *Construction and Building Materials*, 96: 368-377.

Wu, L., Farzadnia, N., Shi, C., Zhang, Z., & Wang, H. (2017). Autogenous shrinkage of high-performance concrete: A review. *Construction and Building Materials*, ***149***:62-75.

Comparative Study on Rice Husk Ash and Silica Fume as Supplementary Cementitious Material in High Performance Concrete Production

Okoh, B.O.[a], Olawuyi, B. J.[b] & Onogwu, C.M.[c]
Department of Building, Federal University of Technology, P.M.B 65, Minna, Nigeria
[a]oka2bless@gmail.com; [b]babatunde@futminna.edu.ng; [c]xtianpepsy@gmail.com
Corresponding email: oka2bless@gmail.com

Abstract

High-Performance Concrete (HPC) utilisation is gaining wide acceptance across the globe due to its high strength, elastic modulus, durability properties and economy. The production process however, requires incorporation of supplementary cementitious materials (SCMs) with Silica fume (SF) mentioned in literature as most adopted. Non-availability of silica fume in the sub-Sahara African countries has necessitated search for local alternative SCMs for HPC production of which Rice husk ash (RHA) has been found readily available with little or no attempt to benchmark its performance level with silica fume. This article thereby reports on a study conducted to establish the comparative effectiveness of Nigeria's RHA as an alternative to SF in HPC production for the development of a sustainable built environment in the era of pandemic. It further examines the effect of pre-soaked pumice in comparison to superabsorbent polymer (SAP) as internal curing (IC) agent on compressive strength of the HPCs. HPC mixes of varied RHA contents (5, 10 and 15% by weight of binder (b_{wob})) were studied and examined for compressive strength in comparison with HPC mix of 7.5% b_{wob} SF content. The IC-agents were kept constant (SAP at 0.2% b_{wob} and pre-soaked pumice at 5% by weight of coarse aggregate (b_{woca}) respectively) for this experiment. The HPC specimen were immersed in water bath for 28 days of curing before testing for compressive strength. The results reveal C_3 (i.e., 5%RHA based-HPC specimen with SAP as IC-agent at 0.2%b_{wob}) had compressive strength value slightly higher (i.e., 0.13%) than the control specimen – C_0 (7.5%SF based-HPC with similar SAP content)

***Keywords:** Rice husk ash (RHA), Silica fume (SF), Superabsorbent polymers (SAP), Pre-soaked lightweight aggregate, and High-performance concrete (HPC).*

Introduction

Pandemic according to world health organization is defined as a disease outbreak that spread across countries. During pandemic, disease spread faster when people live in a clustered environment, sharing same item together resulting from inadequate housing due to high cost of building materials. A way out to tackle this problem is conversion and utilization of the locally available eco-friendly materials for the development of sustainable built environment.

Concrete is a composite material composed of aggregates bonded together with a fluid cement that hardens over time, and is one of the most frequently used building materials according to Mudashiru *et al*. (2021) and its usage worldwide, ton for ton, is twice that of steel, wood, plastic and aluminium combined. It is classified into different forms according to their properties such as normal concrete (NC) with maximum strength of 50 N/mm^2, but development of quality, deterioration and premature failure of the NC brought about the high strength / high-performance concrete (HSC/HPC) up to ultra-high strength concrete (UHSC), having minimum strength of 50 N/mm^2 (Mudashiru *et al*., 2021).

There is a growing acceptance of HSC/HPC in the construction industry across the globe within the past four decades. Although, there is a thin line of difference in these terms, there exists a shift from "high strength concrete property" to "high modulus of elasticity, "high density, "low permeability," and "resistance to attacking ions," which defined HPC (Neville & Aitcin, 2004). American Concrete Institute, ACI (1999) defined HPC "as concrete meeting special combinations of performance and uniformity requirements that cannot always be achieved routinely using traditional constituents, normal mixing, placing, and curing practice. The applications of this type of concrete have majorly been witnessed in the construction of tunnels, precast pylons, bridges, shotcrete repairs, tall buildings, parking garages, and more (Aitcin, 2004; Orosz, 2017).

Nduka *et al.* (2020) reported that when HPC is used in the structures as mentioned above, thinner members are achieved, giving rise to the aesthetically appealing structure. The realisation of slender structural members amounts to less steel, reducing the entire structure's pressure and more functional spaces in buildings. Architects and designers can achieve greater architectural freedom, nearly unlimited structural shapes, form, and near-free reinforcement bars resulting in labour and cost lowering. Self-healing possibility in cracking situations can be produced by a considerable amount of unreacted cement in the finished product (Wang *et al*., 2015). Furthermore, the utilisation of HPC in construction projects has been noted to account for the early removal of shuttering, culminating in early project completion. Many demonstrated construction projects had been accomplished using HPC in many countries (Aitcin, 2004; Abass *et al*., 2016). Thus, the applicability of HPC in a developing country like Nigeria would improve infrastructure projects' future performances.

Previous studies (Persson, 1997; Kovler & Jensen, 2005; Bentz & Weiss, 2011; Di Bella *et al*., 2012; Di Bella *et al*., 2016; Mudashiru *et al*., 2021) empirically revealed that HPC is essentially a concrete with a low-water-to-binder ratio (W/B) ranging from 0.2 - 0.38. The substantial amount of cement and supplementary cementitious materials (SCMs) inherent in the mix results in increased temperature upon water addition and densification within the concrete area. Savva *et al*. (2018) inferred a direct relationship between ambient temperature and cementitious materials' pozzolanic activity. The study posits that cementitious grains are usually influenced by ambient temperature, hence a fast reaction that hinders the uniform distribution of hydration products leading to increased porosity of hydrated gel. In the same vein, SCM's inclusion furthers the propagation of autogenous shrinkage (AGS), chemical shrinkage, and self-desiccation due to combined effects of hydration and pozzolanic reaction necessitating higher moisture demand in the concrete (Wu *et al*., 2017). Additionally, Nduka *et al*. (2018) observed issues of concern like difficulty in curing vertical members, inaccessible locations in buildings, and poor craft when external curing methods are used in HPC structures. Consequently, to mitigate these challenges in concrete production, an innovative curing technique termed "internal curing (IC)" has gained tremendous attention in literature and practice in producing HPC and two notable materials (lightweight aggregates [LWA] and superabsorbent polymers [SAP]) have been used in past studies and practices in advancing the IC process.

Irrespective of the notable improved microstructural, mechanical, and durability properties of HPC, its usage has been limited in construction projects, especially in developing countries due to several reasons. These may be associated with the high cost of production, unavailability of SCMs, early age cracking potentials, and ultimately, lack of awareness by prominent professionals in the built environment (Nduka *et al*., 2018). Consequently, to drive the application of HPC in other regions of the world, extensive research has been conducted to reduce especially the cost components and early-age cracking of HPC. Rice husk ash (RHA) calcined in a controlled environment have been incorporated and investigated in HPC production (Olawuyi *et al*., 2021, Mudashiru *et al*., 2021). In contrast, IC, either with SAP or LWA, has been implemented to control early age cracking. Thus, to practically innovate the use of HPC with locally available material like Nigeria pre-soaked pumice as LWA and RHA as SCM in comparison with SAP and SF (already adjudged as effective IC agent and SCM) in the Nigerian built environment (Mudashiru *et al.*, 2021). HPC mixtures behaviour with this material needs to be examined for physical, chemical and compressive strength properties. Accordingly, this study is set out to investigate the influence of RHA as sustainable building materials in era of COVID19 on Class 1 (C55/67) HPC internally cured with Nigeria pre-soaked pumice in comparison with SF and SAP as a foreign SCM and IC agent respectively.

Materials and Methods

Materials

The materials that were used for this study are: the binders (PC, RHA and SF), aggregates (fine and coarse aggregates), internal curing agents (SAP and presoaked pumice), superplasticizer and water.

The PC used for this study was CEM II 42.5N (3X Dangote brand) whose properties conform to the Nigerian Standard --- and British Standard (BS EN 197-1: 2016) bought from a cement store in Gidan-Kwano, Minna, Niger State.

The RHA on the other hand which serve as (SCM) was obtained from the incineration of the husk using the locally available incinerator at the Concrete Laboratory of the Department of Building, Federal University of Technology, Minna, Niger State. The husk was burnt in an open air for about 24 hrs with a temperature about 700°C and then allow to cool before harvesting and milling with grinding machine. In accordance to ASTM C430- 2014, the milled RHA was sieved using 75 µm sieve and stored in an airtight polythene bag. The SF which serves as the second SCM was purchased from purechem Construction Chemical company in Lagos.

A natural sand with particle size not more than 300 µm according to (Shetty 2004, Neville, 1998, Nduka *et al*., 2020; Olawuyi *et al*., 2021 was used as the fine aggregate in this study for the production of HPC. To obtain values for the physical properties (fineness modulus (FM); coefficient of uniformity (Cu); coefficient of curvature (Cc); and dust content) of the natural sand, PSD was used using sieve analysis technique while the specific gravity was determined in accordance to EN 12390-7. The coarse aggregate used for the study was crushed granite stone which passed through 13.50 mm sieve size and retained on at least 9.50 mm sieve size. The coarse aggregate was washed to remove dust particle and to prevent more water absorption.

A Superabsorbent polymer (labelled FLOSET 27CS) of ≤ 600 µm grain size produced in France by SNF Floerger was added at 0.2% by weight of binder (b_{wob}) as detailed in Olawuyi *et al*., (2021) considering 12 g/g as the SAP absorption capacity conforming to the requirement of SAP specification for the production of HPC determined by tea-bag test (Olawuyi *et al*., 2021). The SAP type used is a thermoset polymer specifically the covalently cross-linked polymers of acrylamide and acrylic acid obtained from bulk solution polymerization and neutralized by alkali hydroxide.

The pre-soaked Pumice used for this study was a porous igneous rock formed as a result of explosives volcanic eruptions. It was crushed and 12.5 mm maximum size was used for this study. The pumice was soaked in water for 24hrs and before using it the water was (Olawuyi *et al*., 2021).

The water used for this study was portable clean water free from dirt and acid. It was gotten from the tap behind the convocation Square of Federal University of Technology, Minna, Niger State.

A Masterglenium polymer-based polycarboxylic ether (PCE) with label (sky 504) supplied by BASF Manufacturing was used as the superplasticizer in this study. It was administered at 1.5% concentration by weight of binder (b_{wob}) as recommended in the work of Olawuyi (2021).

Methods

Properties of Constituent Materials

The oxide content of binders (RHA, SF & PC) , X-ray Fluorescent (XRF) at the National Geoscience Research Laboratory, Kaduna State was used for data acquisition regarding their oxide composition. After calcination, milling and sieving of the binders, 100g for each of the binder was packaged in sealed polythene bags and sent to the Laboratory for the determination of the oxide compositions in accordance with BS EN 196-6: 2016. Wet sieving method was used to determine the particle size distribution of the aggregate's samples, while the specific gravity of the aggregate and binders were determined in the Building Laboratory of FUT, Minna in accordance with EN 12390-7.

Production of HPC Specimen

The production of the HPC specimen was carried out in accordance with the work of Nduka *et al*., 2020, and Olawuyi *et al*., 2021. Mean target strength of C55/67 at 28 days was adopted as the mix design procedure for material proportioning. Table 1 below gives the full details regarding mix proportions used for HPC specimen production. 0.2%b_{wob}) SAP was used for the SAP internally cured HPCs with 12.5g/g additional water provided for SAP absorption while 5% pre-soaked saturated pumice was measured and used for the pumice internally cured HPCs. De-moulding of the 100 mm cube HPC was done After 24 hours of casting. After de-moulding, the specimens were cured by full immersion in ordinary water and after 28days, HPC specimens were removed from the curing tank before subjecting it to compressive testing machine.

Table 59: Mix Proportioning of the HPC

	Materials (kg/m³)								
Label	PC	SF	RHA	F/A	C/A	Pumice	SAP	SP	W/B
C_0	499.5	40.5	-	700	1050	-	1.08	8.1	0.3
C_1	499.5	40.5	-	700	997.5	52.5	-	8.1	0.3
C_2	513	-	27	700	997.5	52.5	-	8.1	0.3
C_3	513	-	27	700	1050	-	1.08	8.1	0.3
C_4	486	-	54	700	997.5	52.5	-	8.1	0.3
C_5	486	-	54	700	1050	-	1.08	8.1	0.3
C_6	459	-	81	700	997.5	52.5	-	8.1	0.3
C_7	459	-	81	700	1050	-	1.08	8.1	0.3

Fresh and Strength Properties

The fresh and compressive strength properties of HPC samples was carried out in accordance to BS EN standards (BS EN 12350 -1 & 5, 2000; 12390-1 & 2, 2000; 12390 - 3, 2002). In accordance with BS EN (12350 - 5 - part 1), for each of the mixtures with 5% pre-soaked pumice and 0.2% SAP, workability test was conducted using Slump Flow Table method to determine the followability of the HPC. Compressive strength test was then were performed on 36 samples after the 28 Days of curing in water at 0.5 N/mm^2 loading rate using 2000 kN loading capacity ELE Compressive Strength Testing Machine with a model number AT-120-1.1.

Results and Discussion

Physical and Chemical Properties

The XRF analysis of the binders (RHA, SF & PC) used for this study in powder form is presented in Table 2. The Table revealed main oxide of the RHA as SiO_2 at 95 % content and that the RHA belong to a Class N Pozzolan having a total useful oxide ($SiO_2 + Al_2O_3 + Fe_2O_3$) content of 95.6 % which is above 70 % minimum as specified in ASTMC 618 (2012).

Table 60: Oxide Composition of Binder Constituents

Oxides	RHA (%)	SF (%)	CEM II (%)
SiO_2	95.0	96.35	25.64
Al_2O_3	0.45	0.47	5.24
Fe_2O_3	0.12	0.28	7.15
CaO	0.84	0.05	60.35
MgO	0.45	0.03	0.41
SO_3	0.10	0.10	0.11
K_2O	1.50	0.02	0.05
Na_2O	0.03	0.02	0.31
M_2O_5	0.05	0.50	0.04
P_2O_5	0.72	0.4	0.03
LOI	0.74	1.52	0.67
$SiO_2 + Al_2O_3 + Fe_2O_3$	95.57	97.10	37.43

The SF sample also has SiO_2 as its major oxide at having a 96.4 % content and a total useful oxide content of 97.1 % implying a very strong and reactive Class F Pozzolan in accordance to ASTM C618. The locally available Nigerian RHA can then be assessed as a strong reactive Pozzolan and good alternative to SF on basis of the oxide content. The PC (CEM II 42.5N) has Calcium Oxide (CaO) at 60.4 % content has the major oxide and conforms to oxides composition for CEM II Portland cement found in literature (Neville, 1998).

The physical properties of the aggregates used are presented in Figure 1 and Table 3. The result revealed that the fine aggregate is in conformity to the Shetty (2004) classification of medium sand with a Coefficient of Uniformity (C_u) of 2.39, Coefficient of Curvature (C_c) of 0.94 and Fineness Modulus

(FM) of 2.88. The coarse aggregates on the other hand, have a C_u of 1.32 and C_c of 0.92 and belong uniformly graded stone classification.

The specific gravity (SG) of the constituent materials (PC, RHA, SF and aggregates) used for this study is presented in Table 4 below. The Table gives the SG values as 3.14 for PC; 2.10 for RHA; 2.24 for SF; 2.62 for sand, 2.68 for granite; and 1.77 for Pumice. The results above conform well to values reported in Neville (1998).

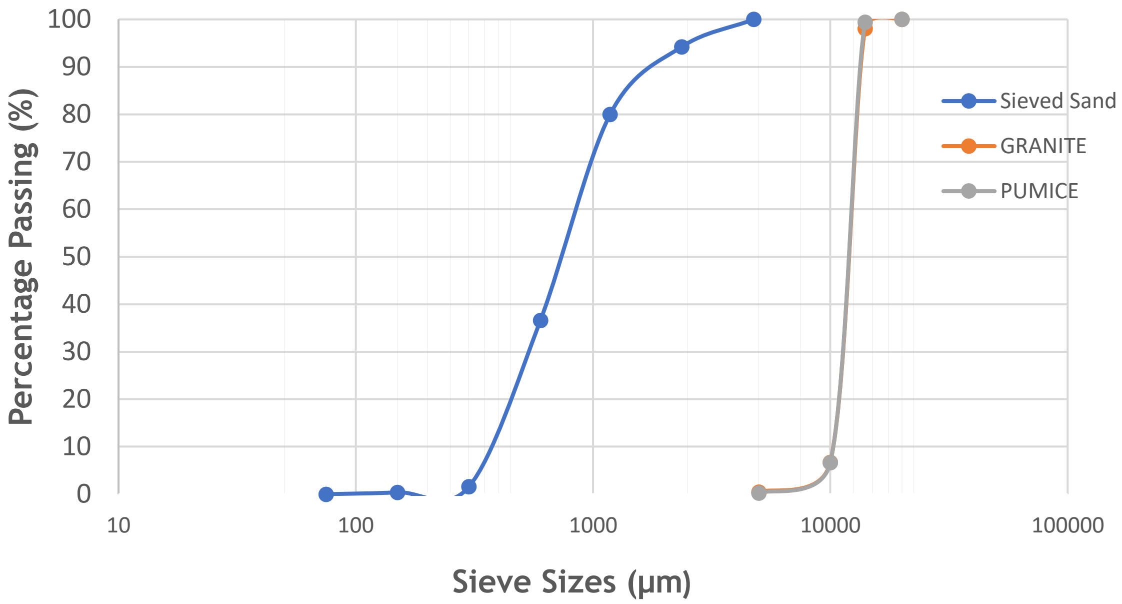


Figure 2: Particle Size Distribution of Aggregates

Table 61: Summary of Particle Size Distribution of Aggregates

Item	Sand	Granite	Pumice
D_{10}	360	10000	10000
D_{30}	540	11000	11000
D_{60}	860	13000	13000
C_u	2.39	1.3	1.3
C_c	0.94	0.93	0.93
FM	2.87		

Table 62: Specific Gravity of PC, MHA, CCW and aggregates

Test	PC	RHA	SF	Sand	Granite	Pumice
Empty cylinder (g) w_1	85	85	85	85	85	85
Empty cylinder + 1/3full of sample (g) w_2	107	96	100	119	119	112
Wt. of empty cylinder + 1/3full of sample + water full (g) w_3	169	160	162	176	176	165
Wt. of bottle + water only to full (g) w_4	154	154	154	154	154	154
SG $=w_2 - w_1/ (w_4 - w_1) - (w_3 - w_2)$	3.14	2.10	2.24	2.85	2.85	1.77

Fresh and strength properties

Results of the slump flow and compressive strength values for the HPC mixtures are presented in Table 5. The Table reveals that the slump flow values increased as the percentage of RHA increases for both HPC with 5% pre-soaked pumice and 0.2% SAP. It further shows that HPC with SAP as internal curing (IC) agent generally has higher slump flow values than the HPCs having pre-soaked pumice as the IC-agent. The higher slump flow of the SAP HPCs with SAP as IC-agent might be due to the additional water added to the mixing water meant to account for SAP absorption. The slump flow values for all HPCs irrespective of the IC-agent used were observed to be within 490 mm and 555 mm affirming that the workability of the HPCs are within the permissible limit of 460 - 600 mm as specified in Neville (1998) for the low W/B concrete.

Table 63: Slump flow and Compressive Strength Values of HPCs

Mix proportion	**C_0**	**C_1**	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**	**C_7**
Slump flow (mm)	510	490	515	525	530	545	550	555
fcu_{cube}	59.86	58.62	58.52	59.94	57.81	59.10	56.05	57.48
% of Control	100.00	97.93	97.76	100.13	96.58	98.73	93.64	96.02

The compressive strength of the internally cured HPCs at 28 days as seen in Table 5 is further presented in Figure 2. The results reveal C3 (i.e., 5%RHA based-HPC specimen with SAP as IC-agent at 0.2%b_{wob}) had compressive strength value slightly higher (i.e., 0.13% as shown in figure 2) than the control specimen – C0 (7.5%SF based-HPC with similar SAP content). The HPC specimen with values for C0, C1, C2, C3, C4, C5, C6 and C7 are 59.86, 58.62, 58.52, 59.93, 57.81, 59.10, 56.05 and 57.48 respectively. The result revealed that as the percentage of RHA increases, the compressive strength decease for both HPCs internally cured with pre-soaked pumice and SAP but the compressive strength of HPCs internally cured with SAP is higher than that internally cured with pre-soaked pumice.

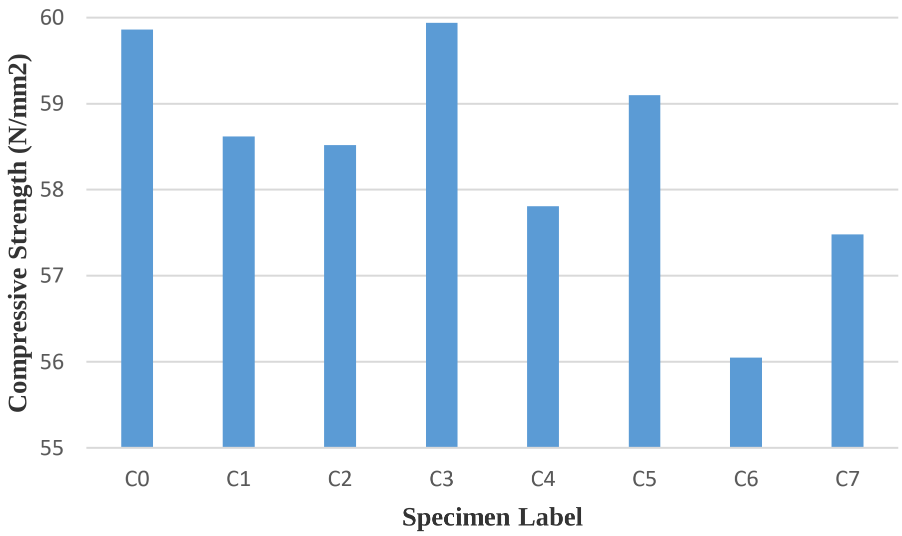


Figure 3: compressive strength of HPCs at 28 days

Conclusion and Recommendation

From the study, the following conclusion was deduced;

6. The RHA is a suitable alternative cementitious material and a good Class N Pozzolan.
7. The HPC with 5%RHA internally cured with 0.2% SAP has a higher value compressive strength when compared with the control (i.e. 7.5%SF internally cured with 0.2% SAP).
8. As the percentage of RHA increases, the compressive strength decreases for both presoaked pumice and SAP internally cured HPCs.
9. 5% content of RHA and 5% pre-soaked pumice are recommended for use as Nigeria local SCM and IC-agent in HPC.

References

Abbas, S., Nehdi, M. L., & Saleem, M. A. (2016). Ultra-high-performance concrete: Mechanical performance, durability, sustainability and implementation challenges. *International Journal of Concrete Structures and Materials*, *10*(3): 271-295.

ACI THPC/TAC (1999), *ACI defines high-performance concrete* (the Technical Activities Committee Report (Chairman - H.G. Russell). U.S.A: American Concrete Institute.

Aïtcin, P. C. (2004). *High-Performance Concrete*. Taylor & Francis e-Library. *New York*.

Bentz D. P. and Garboczi E. J. (2018). Simulation studies of the effects of mineraladmixtures on the cementpaste-aggregate iinterfacialzone, *AmericaConcrete Institute Materials Journal*88(5), 518-529.

Bentz, D. P., & Weiss, W. J. (2011). *Internal curing: a 2010 state-of-the-art review*. Gaithersburg, Maryland: US Department of Commerce, National Institute of Standards and Technology.

BS EN (2016). 197-1, Cement-Part 1: Composition, specifications and conformity criteria for common cements. *British Standards Institution*.

BSEN (2019). 12390-3: 2019. Testing Hardened Concrete. *Compressive Strength of Test Specimens; British Standard Institute: London, UK*.

Di Bella, C., Griffa, M., Ulrich, T. J., & Lura, P. (2016). Early-age elastic properties of cement-based materials as a function of decreasing moisture content. *Cement and Concrete Research*, ***89***: 87-96.

Kovler, K., & Jensen, O. M. (2005). Novel techniques for concrete curing. *Concrete International*, 27(09): 39-42.

Mudashiru, S. A., Olawuyi, B. J., Ayegbokiki, S. T., Ndayako, S. K. (2021). Influence of magnesium sulphate on compressive strength of rice husk ash based high performance concrete in: *Proceedings of the 3rd School of Environmental Technology International Conference on Sustainable and House Management*, 271-278.

Nduka, D. O., Ameh, J., Joshua, O., & Ojelabi, R. (2018). Awareness and Benefits of Self-Curing Concrete in Construction Projects: Builders and Civil Engineers Perceptions. *Buildings*, 8(8): 109.

Nduka, D. O., Olawuyi, B. J., Mosaku, T. O., & Joshua, O. (2020). Influence of Superabsorbent Polymers on Properties of High-Performance Concrete with Active Supplementary Cementitious Materials of Nigeria. In *International Conference on Application of Superabsorbent Polymers & Other New Admixtures Towards Smart Concrete*, *65*-74. Springer, Cham.

Neville, A., & Aitcin, P. C. (1998). High-performance concrete—an overview. *Materials and Structures*, ***31***(2): 111-117.

Olawuyi, B. J., Babafemi, A. J., & Boshoff, W. P. (2021). Early-age and long-term development of high-performance concrete with SAP: Building and Materials. 267 (2021) 121798. www.elsevier.com/locate/conbuildmat.

Orosz, K. (2017). Early Age Autogenous Deformation and Cracking of Cementitious Materials—Implications on Strengthening of Concrete. Ph.D. Dissertation, Luleå Tekniska Universitet, Luleå, Sweden.

Persson, B. (1997). Self-desiccation and its importance in concrete technology. *Materials and Structures*, *30*(5): 293-305.

Savva, P., Nicolaides, D., &Petrou, M. F. (2018). Internal curing for mitigating high-temperature concreting effects. *Construction and Building Materials*, ***179***: 598-604.

Shetty, M. S. (2004), Concrete technology - theory and practice, New Delhi, India: S. Chand and Company Limited Technology (pp. 219 - 228)., Midrand, South Africa: *Cement and Concrete Institute.*, 219-228.

Wang, D., Shi, C., Wu, Z., Xiao, J., Huang, Z., & Fang, Z. (2015). A review on ultra-high-performance concrete: Part II. Hydration, microstructure and properties. *Construction and Building Materials*, 96: 368-377.

Wu, L., Farzadnia, N., Shi, C., Zhang, Z., & Wang, H. (2017). Autogenous shrinkage of high-performance concrete: A review. *Construction and Building Materials*, ***149***:62-75.

Development of Scheffe's Regression Model to Predict the Compressive Strength of Concrete Using Metakaolin as Partial Replacement of Cement

Jegede, A.[1a], Adejumo, T. W.[1b], Oritola, S. F.[1c], Shehu, M.[1d], Omojah, A.[1e] & Mahmud, M. B.[2]
[1]*Department of Civil Engineering, Federal University of Technology, Minna, Niger State, Nigeria*
[2]*Department of Civil Engineering, Federal Polytechnic Bida, Niger State, Nigeria*
Corresponding author email: jwastecx@gmail.com; (+2348169492682)

Abstract
Kaolinite clay, that Nigeria has been proven to have about 3 billion tonnes scattered across all the geo-political zone, can be used to produce Metakaolin through a simple calcinations process. Metakaolin may be used as a cement replacing material in concrete, to reduce cement consumption, to increase strength and the rate of strength gain, to decrease permeability and to improve durability. In this study, it served as a fifth component of concrete blend as it replaces between 0% to 20% of cement. The other four ingredients were water, cement, fine aggregates (sand), coarse aggregates(granite). Scheffe's simplex theory was used for the five-mix design in a {5,2} experimental design which resulted in an additional ten mix ratios. For the purpose of testing and verification, additional fifteen mix ratios were made. The thirty concrete mix ratios were subjected to laboratory experiment to determine the 28days compressive strengths. The results of the first fifteen compressive strengths (model mixes) were used for the calibration of the model constant coefficients, while those from the second compressive strength (control mixes) were used for the model verification. A mathematical scheffe's regression model was derived from the experimental results, which was used to predict the compressive strength of concrete. The regression model was subjected to a t-test with 5% significance, which ascertain the model to be adequate with an R^2 value of 0.9417. The study reveal that Metakaolin can replace up to 20% of cement without compromising 28-day compressive strength.

Keyword: *Concrete, Cement, Metakaolin, Strength, Model, Kaolinite*

Introduction

Concrete is one of the most widely used construction materials in the world, with 2.8 billion tons placed worldwide each year (Schneider *et al*., 2011). It is attractive in many applications because it offers considerable strength at a relatively low cost. Concrete can generally be produced of locally available constituents. It can be cast into a wide variety of structural configurations, and requires minimal maintenance during service (Najimi *et al*., 2012). Portland cement industry is responsible for approximately 8% of global CO_2 emission (Report, C. H., 2018). Partial replacement of Portland cement by one or more additives to obtain blended cements not only provides reduction in CO_2 emission and energy saving in cement production but also supplies more durable cementitious system to the construction industry.

Supplementary cementitious materials (SCMs) are finely ground solid materials that are used to replace part of cement in a concrete mixture. These materials react chemically with hydrating cement to form a modified paste microstructure. In addition to their positive environmental impact, SMCs may improve concrete workability, mechanical properties, and durability.

Metakaolin (MK) is produced by controlled thermal treatment of kaolin. Different researchers have introduced different optimum temperature (600–850 ° C) and period (1–12h) for heating kaolin to obtain MK with a high pozzolanic index. Therefore, MK can replace cement in concrete because of it pozzolanic properties (Elavarasan *et al*., 2020). When used in concrete, metakaolin undergoes a pozzolanic reaction and refines the microstructure of the hydrated cement paste. Due to the small particle size and high surface area, MK reacts quickly and reduces the diffusion coefficient compared with plain Portland cement (Basheer *et al*., 2002). Research suggests that Silica fumes and MK have similar influences on the chloride ingress resistance of concrete. Typical replacement levels for MK range from 5% to 10% (Holland *et al*., 2016).

Modeling involves setting up mathematical formulations of physical or other systems. Such formulations are constructed for the assessment of the objective function after the hindsight of observed operating variables. Hence or otherwise, model could be constructed for a proper observation of response from the integration of the factors through controlled experimentations followed by schematic design where such simplex lattice approach of the type of Scheffe (1958) optimization theory could be employed. Entirely different physical systems may correspond to the same mathematical model so that they can be solved by the methods. This study seeks to develop a mathematical regression model known as the Scheffe's model to predict the compressive strength of concrete when cement is partially replaced Metakaolin (MK).

2.0 Materials and Methods

2.1 Materials

The materials used to achieve the aim of this study include the following;

i Kaolin clay

The kaolin clay was gotten from Kuta and synthesis into Metakaolin (MK) at the material lab, Bosso campus of the Federal University of Technology Minna

ii Ordinary Portland cement (OPC)

The Ordinary Portland cement of Dangote brand was obtained from an open Market and conforms to BS 12, (1996).

iii Coarse aggregates

The coarse aggregates obtained from a quarry in Maikunkele, Bosso Local Government Area, Niger State, grading of the aggregate was carried out to BS 882, (1992)

iv Fine aggregates

The fine aggregate was obtained from a river behind the boy's hostel Gidan Kwano Campus, Federal University of Technology Minna. The grading of the aggregate was carried out to BS 812, (1985)

v Potable water

The potable water used was obtained from the University water mains free from impurities.

2.2 Method

i Scheffe's simplex theory

A lattice is purely an abstract space to achieve the desired strength of concrete. The major factor lies on the adequate proportioning of ingredients needed to make concrete. The simplex approach considers a number of components, *q*, and a degree of polynomial, *m*. The sum of all the *ith* components is not greater than 1. Hence,

$$X_1 + X_2 + \cdots + X_{q-1} + X_q = 1 \quad (that\ is\ 100\%) \tag{1}$$

$$\sum_{i=1}^{q} x_i = 1 \tag{2}$$

with $0 \leq x \leq 1$. The factor space becomes S_{q-1}. According to (Scheffe, 1958), the {*q*, *m*}

simplex lattice design is a symmetrical arrangement of points within the experimental region in a suitable polynomial equation representing the response surface in the simplex region.

The number of points $C_m^{(q+m-1)}$ has (m+1) equally spaced values of $X_i = 0, \frac{1}{m}, \frac{2}{m}, \ldots \frac{m}{m}$.

$$N = \frac{(q+m-1)!}{m!\,(q-1)!} \tag{3}$$

For a polynomial of degree *m* with *q* component variables where Equation (3. 2) holds, the general form is:

$$Y = b0 + \sum b_i x_i + \sum b_{ij} x_i x_j + \sum b_{ijk} x_i x_j x_k + \dots + \sum b_{i1,i2..in} x_{i1} x_{i2} x_{in} \tag{4}$$

Where $1 \le i \le q$, $1 \le i \le j \le q$, $1 \le i \le j \le k \le q$, and b_0 is the constant coefficient.

x is the pseudo component for constituents *i*, *j*, and *k*.

When $\{q,m\} = \{5,2\}$, Equation (3.5) becomes:

$$Y = \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \beta_{12} x_1 x_2 + \beta_{13} x_1 x_3 + \beta_{14} x_1 x_4 + \beta_{15} x_1 x_5 + \beta_{23} x_2 x_3 + \beta_{24} x_2 x_4 + \beta_{25} x_2 x_5 + \beta_{34} x_3 x_4 + \beta_{35} x_3 x_5 + \beta_{45} x_4 x_5 \tag{5}$$

$$Y = \sum_{i=1}^{s} \beta_i x_i + \sum_{1 \le i \le j \le 5} \beta_{ij} x_i \tag{6}$$

Where the response, Y is a dependent variable (compressive strength of concrete). Equation (5) is the general equation for a {*5*, *2*} polynomial, and it has 15 terms, which conforms to Scheffe's theory in Equation (3)

Let Y_i denote response to pure components, and Y_{ij} denote response to mixture components in *i* and *j*. If x_i=1 and x_j= 0, since $j \neq i$, then.

$$Y_i = \beta_i \tag{7}$$

This means that;

$$\sum_{i=1}^{s} \beta_i x_i = \sum_{i=1}^{s} Y_i x_i \tag{8}$$

Hence, from Equation (3.14)

$$Y_1 = \beta_1,\ Y_2 = \beta_2,\ Y_3 = \beta_3,\ Y_4 = \beta_4 and\ Y_5 = \beta_5 \tag{9}$$

According to Scheffe (1958),

$$\beta_{ij} = 4Y_{ij} - 2\,Y_i - 2\,Y_j \tag{10}$$

1.1.1 Concrete mix design

The Department of Environment (DoE, 1988) mix design was adopted for the preparation of the concrete due to its versatility and applications in different concrete structures such as buildings, roads and bridges. Five different mix proportions were produced by replacing cement with Metakaolin (MK) from 0 to 20% respectively. The following results were obtained;

In order to satisfy the requirement of a 5, 2 Scheffe's model, the following five mix ratios of Water: Cement: MK: FA: CA were generated from a five-mix design in 3.3.2:

$$A1 = [0.50, 1.00, 0.00, 1.65, 2.78],\ A2 = [0.48, 0.95, 0.05, 1.54, 2.64],\ A3 = [0.46, 0.90, 0.10, 1.46, 2.50],\ A4 = [0.52, 0.85, 0.15, 1.69, 2.91],\ A5 = [0.54, 0.80, 0.20, 1.77, 3.05 \tag{2.2.1}$$

The corresponding pseudo components are:

$$X1 = [1,0,0,0,0], X2 = [0,1,0,0,0], X3 = [0,0,1,0,0], X4 = [0,0,0,1,0], X5 = [0,0,0,0,1] \tag{2.2.2}$$

Substituting X_i and S_i into equation 3.23 and transposing the values of A matrix were obtained as

$$[S] = \begin{bmatrix} 0.50 & 0.48 & 0.46 & 0.52 & 0.54 \\ 1.00 & 0.95 & 0.90 & 0.85 & 0.80 \\ 0.00 & 0.05 & 0.10 & 0.15 & 0.20 \\ 1.65 & 1.54 & 1.46 & 1.69 & 1.77 \\ 2.78 & 2.64 & 2.50 & 2.91 & 3.05 \end{bmatrix} \quad (2.2.3)$$

With the binary points or centre points

$$X12 = [0.5, 0.5, 0, 0, 0]\,, X13 = [0.5, 0, 0.5, 0, 0], X14 = [0.5, 0, 0, 0.5, 0], X15 = [0.5, 0, 0, 0, 0.5]$$

$$X23 = [0, 0.5, 0.5, 0, 0], X24 = [0, 0.5, 0, 0.5, 0], X25 = [0, 0.5, 0, 0, 0.5], X34 = [0, 0, 0.5, 0.5, 0]$$

$$X35 = [0, 0, 0.5, 0, 0.5], X45 = [0, 0, 0, 0.5, 0.5 \quad (2.2.4)$$

According to Scheffe (1958),

$$S_{ij} = XS_i \quad (2.2.5)$$

Substituting,

$$\begin{bmatrix} S_{12} \\ S_{13} \\ S_{14} \\ S_{15} \\ S_{23} \end{bmatrix} = \begin{bmatrix} 0.5 & 0.5 & 0.0 & 0.0 & 0.0 \\ 0.5 & 0.0 & 0.5 & 0.0 & 0.0 \\ 0.5 & 0.0 & 0.0 & 0.5 & 0.0 \\ 0.5 & 0.0 & 0.0 & 0.0 & 0.5 \\ 0.0 & 0.5 & 0.5 & 0.0 & 0.0 \end{bmatrix} \begin{bmatrix} 0.50 \\ 0.48 \\ 0.46 \\ 0.52 \\ 0.54 \end{bmatrix} \quad (2.2.6)$$

This process was repeated for S_{24}, S_{25}, S_{34}, S_{35} and S_{45}. Similarly, the process was repeated for an additional 15 control points that will be used for the verification of the formulated model.

***Table 1**: Actual and pseudo mix ratios of the model*

	Actual Components					**Resp.**	**Pseudo Components**				
S	W	C	MK	FA	CA	(Y_{exp})	X_1	X_2	X_3	X_4	X_5
N_1	0.50	1.00	0	1.65	2.78	Y_1	1	0	0	0	0
N_2	0.48	0.95	0.05	1.54	2.64	Y_2	0	1	0	0	0
N_3	0.46	0.90	0.10	1.46	2.50	Y_3	0	0	1	0	0
N_4	0.52	0.85	0.15	1.69	2.91	Y_4	0	0	0	1	0
N_5	0.54	0.80	0.20	1.77	3.05	Y_5	0	0	0	0	1
N_{12}	0.49	0.975	0.025	1.595	2.71	Y_{12}	0.5	0.5	0	0	0
N_{13}	0.48	0.950	0.05	1.555	2.64	Y_{13}	0.5	0	0.5	0	0
N_{14}	0.51	0.925	0.070	1.67	2.845	Y_{14}	0.5	0	0	0.5	0
N_{15}	0.52	0.90	0.10	1.70	2.915	Y_{15}	0.5	0	0	0	0.5
N_{23}	0.47	0.925	0.075	1.50	2.57	Y_{23}	0	0.5	0.5	0	0
N_{24}	0.50	0.90	0.1	1.615	2.775	Y_{24}	0	0.5	0	0.5	0
N_{25}	0.51	0.875	0.125	1.655	2.845	Y_{25}	0	0.5	0	0	0.5
N_{34}	0.49	0.875	0.125	1.575	2.705	Y_{34}	0	0	0.5	0.5	0
N_{35}	0.50	0.850	0.15	1.615	2.775	Y_{35}	0	0	0.5	0	0.5
N_{45}	0.53	0.825	0.175	1.73	2.98	Y_{45}	0	0	0	0.5	0.5

***Table2:** Actual and pseudo mix ratios of control observation points*

Actual Components	**Resp.**	**Pseudo Components**

S	W	C	MK	FA	CA	(Y_{exp})	X_1	X_2	X_3	X_4	X_5
C_1	0.514	0.895	0.105	1.678	2.871	Y_1	0.3	0	0	0.7	0
C_2	0.478	0.945	0.055	1.538	2.626	Y_2	0.2	0.5	0.3	0	0
C_3	0.476	0.940	0.06	1.536	2.612	Y_3	0.4	0	0.6	0	0
C_4	0.50	0.90	0.10	1.622	2.776	Y_4	0.2	0.2	0.2	0.2	0.2
C_5	0.49	0.935	0.065	1.587	2.708	Y_5	0.3	0.3	0.2	0.2	0
C_{12}	0.488	0.970	0.03	1.584	2.696	Y_{12}	0.4	0.6	0	0	0
C_{13}	0.486	0.915	0.085	1.565	2.68	Y_{13}	0.1	0.4	0.3	0.1	0.1
C_{14}	0.472	0.93	0.070	1.517	2.584	Y_{14}	0.3	0	0.7	0	0
C_{15}	0.464	0.91	0.09	1.476	2.528	Y_{15}	0	0.2	0.8	0	0
C_{23}	0.504	0.92	0.08	1.642	2.805	Y_{23}	0.3	0.4	0	0	0.3
C_{24}	0.496	0.99	0.01	1.631	2.752	Y_{24}	0.9	0	0.1	0	0
C_{25}	0.49	0.905	0.095	1.577	2.707	Y_{25}	0	0.5	0.2	0.2	0.1
C_{34}	0.496	0.97	0.03	1.624	2.751	Y_{34}	0.7	0.1	0.1	0.1	0
C_{35}	0.508	0.94	0.06	1.666	2.832	Y_{35}	0.6	0	0	0.4	0
C_{45}	0.496	0.91	0.09	1.61	2.749	Y_{45}	0.3	0.1	0.3	0.1	0.2

3.0 Results and Discussion

3.1 Compressive Strength of Concrete

Three replicate concrete cubes were cast for each of the thirty mix ratios using $150mm$ moulds. The cubes were removed after 24 hours from the mould and were soaked in water to cure for 28 days. The cubes were removed on the 28^{th} day and subjected to crushing with the help of a uniaxial compressive strength machine. The compressive strength was determined with Equation (3.36)

$$F_c = \frac{P}{A} \quad (3.1.1)$$

Where;

Fc = compressive strength of concrete, P = the applied compressive load at failure (kN)

A = the cross-sectional area of the specimen (mm^2)

For the average loads of mix, A, B and C with a constant cube cross sectional area of 22500mm^2, the compressive strength for the various sample points was presented in Figure 1.

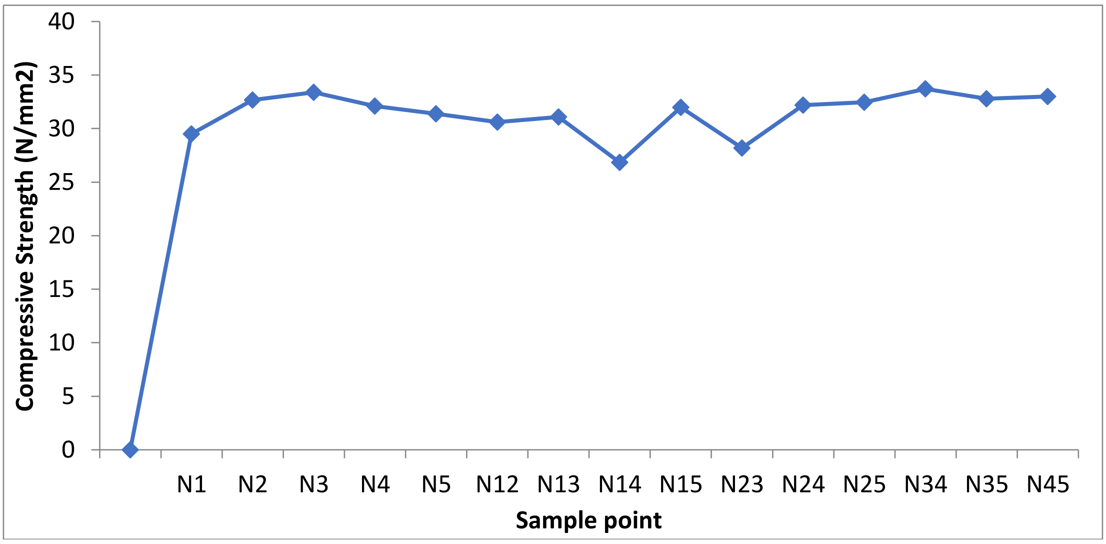


Figure 1: Compressive Strength of Cubes

3.2 Scheffe's model for 28 days compressive strength

The coefficients of polynomials from Table 3.1.1 substituted into the

Equation (2.2.1.14) and Equation (2.2.1.15) are:

$$\beta_1 = 29.51, \quad \beta_2 = 32.66, \quad \beta_3 = 33.39, \quad \beta_4 = 32.11, \quad \beta_5 = 31.40$$

Recall from equation 3.18 that, $\beta_{ij} = 4\,Y_{ij} - 2\,Y_i - 2\,Y_j$

$\beta_{12} = 4\,Y_{12} - 2\,Y_1 - 2\,Y_2$

$\beta_{12} = 4(30.6) - 2(29.51) - 2(32.66) = -1.94$

Similarly, $\beta_{13} = -1.4$, $\beta_{14} = -15.84$, $\beta_{15} = 6.1$, $\beta_{23} = -19.3$, $\beta_{24} = 0.74$,

$\beta_{25} = 1.72$, $\beta_{34} = 3.84$, $\beta_{35} = 1.62$, $\beta_{24} = 4.94$

Substituting the above coefficients into equation (2.2.1.10)

$$Y = 29.51x_1 + 32.66x_2 + 33.99x_3 + 32.11x_4 + 31.40x_5 - 1.94x_1x_2 - 1.4x_1x_3 - 15.84x_1x_4 + 6.1x_1x_5 - 19.3x_2x_3 + 0.74x_2x_4 + 1.72x_2x_5 + 3.84x_3x_4 + 1.62x_3x_5 + 4.94x_4x_5 \qquad (3.2.1)$$

Equation (1) above is the mathematical model to predict the 28 days compressive strength of concrete using MK to replace 0-20% of cement.

Table 3: *Experimental and predicted values of 28 days compressive strength for the model mix*

Sample Points	Response	PSUEDO COMPONENTS					comp. strength	comp. strength
	Y	W/C	C	MK	F. A	C. A	Yexp. (N/mm^2)	Ypred. (N/mm^2)
		X_1	X_2	X_3	X_4	X_5		
N1	Y1	1.0	0.0	0.0	0.0	0.0	29.51	29.51
N2	Y2	0.0	1.0	0.0	0.0	0.0	32.66	32.66
N3	Y3	0.0	0.0	1.0	0.0	0.0	33.99	33.39
N4	Y4	0.0	0.0	0.0	1.0	0.0	32.11	32.11
N5	Y5	0.0	0.0	0.0	0.0	1.0	31.40	31.40
N12	Y6	0.5	0.5	0.0	0.0	0.0	30.60	30.60
N13	Y7	0.5	0.0	0.5	0.0	0.0	31.40	31.10
N14	Y8	0.5	0.0	0.0	0.5	0.0	26.85	26.85
N15	Y9	0.5	0.0	0.0	0.0	0.5	31.98	31.98
N23	Y10	0.0	0.5	0.5	0.0	0.0	28.50	28.20
N24	Y11	0.0	0.5	0.0	0.5	0.0	32.57	32.20
N25	Y12	0.0	0.5	0.0	0.0	0.5	32.46	32.46
N34	Y13	0.0	0.0	0.5	0.5	0.0	34.42	33.71
N35	Y14	0.0	0.0	0.5	0.0	0.5	32.70	32.80
N45	Y15	0.0	0.0	0.0	0.5	0.5	32.99	32.99

Table 4*: Experimental and predicted values of 28 days compressive strength for the control mix*

Sample Points	Response Y	PSUEDO COMPONENTS					comp. strength	comp. strength
		W/C	C	MK	F. A	C. A	Yexp. (N/mm^2)	Ypred. (N/mm^2)
		X1	X2	X3	X4	X5		
C1	Y1	0.3	0.0	0.0	0.7	0.0	29.94	28.00
C2	Y2	0.2	0.5	0.3	0.0	0.0	29.37	29.26
C3	Y3	0.4	0.0	0.6	0.0	0.0	30.14	31.86
C4	Y4	0.2	0.2	0.2	0.2	0.2	30.38	31.15
C5	Y5	0.3	0.3	0.2	0.2	0.0	30.08	29.77
C12	Y6	0.4	0.6	0.0	0.0	0.0	28.55	30.93
C13	Y7	0.1	0.4	0.3	0.1	0.1	27.97	30.34
C14	Y8	0.3	0.0	0.7	0.0	0.0	29.25	32.35

C15	Y9	0.0	0.2	0.8	0.0	0.0	30.53	30.64
C23	Y10	0.3	0.4	0.0	0.0	0.3	29.85	31.86
C24	Y11	0.9	0.0	0.1	0.0	0.0	30.19	29.83
C25	Y12	0.0	0.5	0.2	0.2	0.1	27.06	31.24
C34	Y13	0.7	0.1	0.1	0.1	0.0	31.17	29.06
C35	Y14	0.6	0.0	0.0	0.4	0.0	27.19	26.75
C45	Y15	0.3	0.1	0.3	0.1	0.2	27.92	31.24

3.0 Conclusion

Results of this research work have been collected within the limits of experimental accuracy, upon which various deductions have been made, these deductions include; The compressive strength of concrete increases on the progressive replacement of cement with Metakaolin (MK)**.** Using Scheffe's (5, 2) polynomial equation, mix design mathematical model for a five component MK blended cement concrete was developed. The model could predict the compressive strength of MK blended concrete when the mix ratios are known and vice versa.

The predictions from the model were tested at 95% accuracy level using statistical Fisher test and found to be adequate. The maximum strength predicted by this model was 33.71 N/mm^{2}derived from a mix ratio of 0.490:0.875:0.125:1.575:2.705 for Water: Cement: MK: FA (Sharp sand): CA (Granite) respectively.

References

Basheer, P., Gilleece, P., Long, A. & Mc Carter, W. (2002). Monitoring electrical resistaance of concrete containing alternative cementious materials to assess their resistance to chloriide penetration. *Cement and Concrete Composites*, 24(5), 437-449.

Elavarasan, S., Priya, A., Ajai, N., Akash, S., Annie, T. & Bhuvana, G. (2020). Experimeter Study on partial replacement of cement by metakaolin and GGBS. Materials Today: Proceedings, 37(part 2), 3527-3530

Holland, R., Kurtis, K.& Kahn, L. (2016). Effect of different concrete materials on the corrosion of the embedded reinforcing steel. In A. Poursaee (Ed.), *Corrosion of Steel in Concrete Structures*. Woodhead publishing, 131-147.

Najimi, M., Sobhani, J., Ahmadi, B.& Shekarchi, M. (2012). An experimental study on durability properties of concrete containing zeolite as a highly reactive natural pozzolan. *Construction and Building Materials,* 1(3), 11.

Report, C. H. (2018). *Making Concrete Change: Innovation in Low-carbon Cement and Concrete.* Chatham House.

Scheffé, H. (1958). *Experiments with mixtures. Journal of the Royal Statistical Society*: Series B (Methodological), 20(2), 344-360.

Schneider, M. R. (2011). Suistainable Cement Production - Present and Future. *Cement and Concrete Research*, 41.

Effect of Vibration on Static and Dynamic Response of Loaded Waffle Slab

Michael, A. A.[1]*, Sadiku, S.S.[2], Mohammed, A.[3] & Aguwa, J.I.[4]

[1]Department of Civil Engineering, University of Ilorin, Nigeria.
[2]Department of Civil Engineering, Federal University of Technology, Minna, Nigeria.
**Corresponding Author: abdulhafizomeiza@gmail.com (08078874482)*

Abstract

With advance in Technology and Sciences, structures are now designed to reduce self-weight, thus, lowering their natural vibration frequency. Waffle slab, which are gradually replacing solid slab in Nigeria is an example of a structures that reduces vibration frequency. This research was carried out to assess the dynamic effect due to aerobic activities on waffle slab using the finite element approach for grid analysis with the aid of MATLAB. Initially, the static analysis and design was done using an ultimate variable load of 8.0 kN/m^2 as recommended by BS 6399. Next, the dynamic analysis was done, which resulted in a low natural frequency (1.65 Hz), which is within the range of forced frequency of vibration due to normal jumping, and within the range liable to cause serious discomfort to humans. Assessment of the dynamic load on the structure gave 45.8 kN/m^2, which is not suitable for application on the waffle slab. It was concluded that waffle slab is not suitable for aerobic activities.

Keywords: Waffle slab, vibration, static, dynamic Loads.

1. Introduction

In constructions such as bridges and multi-story buildings, floor slabs fulfill several crucial structural purposes. They not only transport gravity loads to the vertical structural systems, such as frames and shear walls, but also resist lateral stresses in conjunction with the structural frames systems. For these two functions, the principal action of the slabs is out-of-plane bending, a subject that has been widely explored. Available easily are the analytical techniques required to forecast out-of-plane slab behaviour (Wang and Salmon, 1985). The second role of slab is to provide a flat surface, support weight, insulate against sound, fire, and heat, and provide resistance. The area between the floor and ceiling may be used to store construction supplies and equipment (Anitha and Rinu, 2017). It is simply a two-dimensional reinforced or unreinforced cement concrete structural element that functions as a floor, a ceiling, or a landing foundation in contemporary building construction.

The construction of waffle slabs is characterized as a mixture of a flat flange plate, or deck, and a system of uniformly spaced parallel ribs, or grillage, which may be placed orthogonally or skew with monolithic cross-sections. They are sometimes referred to as two-way ribbed flat slabs and have niches between the ribs. Waffle slabs provide economic and structural advantages (Akshay and Riyaz, 2015). Due of their greater stiffness and lower deflection, they are used for constructions with severe loads and long spans. As a consequence, waffle slabs have become popular in office buildings, hotels, auditoriums, vestibules, theatre halls, and retail showrooms where column-free space is often the primary need. Living in a modern world and understanding that the world is a global village, the speed of conception and execution of Civil Engineering structures necessitates a well-grounded module for Civil Engineering structures that require complex analysis and design. In a rapidly developing and technologically advancing world, it is essential to do so with extreme precision and precession.

Therefore, when compared to the applied dead and imposed loads, the self-weight of long span, solid reinforced concrete slabs longer than 5 meters are excessive, resulting in an uneconomical manner of construction. Using ribbed slabs is a significant method of solving this issue. A ribbed slab is a slab in which underlying spaces have been added to minimize dead weight and boost the efficiency of the concrete section (Abejide and Konitufe, 2015). These stronger flooring need a somewhat deeper section, but they permit longer spans and the incorporation of holes. These greater spans are economical between 8 and 12 meters. Some complexities in formwork tend to counterbalance the material savings (BS 8110, 1997).

This study focuses on aerobic activities in which gymnastics, dancing, and leaping and foot-stamping are routinely practiced at the basket and volleyball court plate in order to analyze the dynamic impact of these rhythmic activities owing to human force stimulation on the floor. This work will elaborate the results obtained from the dynamic loads study conducted on the waffle floor system by obtaining the most waffle slabs design variables using the BS 8110, (1997) and design requirements, such requirements may include safety of the structure against collapse, limitation on damage or on deflection, or any number of other criteria. These are the bare minimum state requirements (Melchers, 1987). During the design phase, accurately analyzed structures are crucial for minimizing construction costs. Exceptional designers must be able to plan and manage the design process with a particular focus on cost efficiency. This thesis outlines such a circumstance that happened in practice, as well as the corrective steps that will be taken (Bachmann, 1992).

1.1 Aim and Objectives of the Study

The aim of this research is to establish a computer aided analysis and design procedure for reinforced concrete waffle slabs subjected to human induced excitation.

Based on the aim, the objectives are to:

i. Analyse the waffle slab under a static ultimate load.

ii. Analyse a model of the forcing function arising from human activities based on field data.

iii. Analyse and design waffle slab subjected to human induced vibration.

iv. Develop a computer programme for analysis and design of waffle slab.

2. Methodology

Among the many approaches available for the study and design of grid systems, finite element analysis is the most precise and trustworthy. The static and dynamic methods of analysis will be described first, then the MATLAB technique for addressing the issue was provided.

2.1 Grids

A grid is a structure on which loads are imposed perpendicular to the structure's plane, as opposed to a plane frame on which loads are delivered in the structure's plane. At the nodes of the grid, both torsional and bending moment continuity are maintained.

2.1.1 Static analysis of grids

The static analysis of grids involves first, the determination of the stiffness matrix, the displacements at the nodes and the forces in members. The degrees of freedom for a grid element are: a vertical displacement (normal to the grid), a torsional rotation about the x-axis, and a bending rotation the z-axis. The degree of freedom for the nodal forces are: a transverse force, a torsional moment about the x- axis, and a bending moment about the z-axis.

2.1.2 Dynamic analysis

The dynamic analysis of a grid may include or exclude the damping effect. In this investigation, dampening force was disregarded. In order to account for the mass of the system during the undamped analysis of the grid, the mass matrix of the system must be integrated with the stiffness matrix. This mass matrix might be lumped or consistent; however, for the sake of achieving a high degree of precision, the consistent mass was used.

2.1.2.1 Torsional effect

The mass matrix coefficient compatible with torsional effects is given by

$$m_{ij} = \int_0^L I_{\bar{m}}(x)\theta_j'(x)dx \qquad (1)$$

In which

$I_{\bar{m}}$ is the polar mass moment of inertial, per unit length along the beam element.

This moment of inertial may conveniently be expressed as the product of the mass $\bar{m}$ per unit length multiplied by the radius of gyration squared, k^2.

The radius of gyration may, in turn, be calculated as the ratio ${}^{I_0}/{}_{A}$. Therefore, the mass polar moment of inertial per unit length is given by:

$$I_{\bar{m}} = \bar{m}\frac{I_0}{A} \tag{2}$$

In which

I_0 is the polar moment of inertial of the cross-section and A the cross-sectional area.

on a uniform beam yields the mass matrix for torsional effect as:

$$\begin{Bmatrix} T_1 \\ T_1 \end{Bmatrix} = \frac{I_{\bar{m}}L}{6}\begin{bmatrix} 2 & 1 \\ 1 & 2 \end{bmatrix}\begin{Bmatrix} \ddot{\delta}_1 \\ \ddot{\delta}_2 \end{Bmatrix} \tag{3}$$

Combining equation 3 with the consistent mass matrix for a beam element, we have

$$\begin{Bmatrix} P_1 \\ P_2 \\ P_3 \\ P_4 \\ P_5 \\ P_6 \end{Bmatrix} = \frac{\bar{m}L}{420}\begin{bmatrix} 156 & 0 & 22L & 54 & 0 & -13L \\ 0 & 140I_0/A & 0 & 0 & 70I_0/A & 0 \\ 22L & 0 & 4L^2 & 13L & 0 & -3L^2 \\ 54 & 0 & 13L & 156 & 0 & -22L \\ 0 & 70I_0/A & 0 & 0 & 140I_0/A & 0 \\ -13L & 0 & -3L^2 & -22L & 0 & 4L^2 \end{bmatrix}\begin{Bmatrix} \ddot{\delta}_1 \\ \ddot{\delta}_2 \\ \ddot{\delta}_3 \\ \ddot{\delta}_4 \\ \ddot{\delta}_5 \\ \ddot{\delta}_6 \end{Bmatrix} \tag{4}$$

Or in concise form,

$$\{P\} = [M_c]\{\delta\} \tag{5}$$

3.0 Analysis and Design

This chapter presents the general arrangement of slab layout, model, analysis and design results of the various entities used for the research work. The modelled slab is presented in Figure 1 with panels ranging from P1, P2, P3, P4 and P5, P6, P7, P8 and P9 respectively. The slab panel P8, in Figure 2 considered is presented first, then the idealized model for analysis, measured weights for dynamic analysis, the section properties and finally the design and serviceability checks.

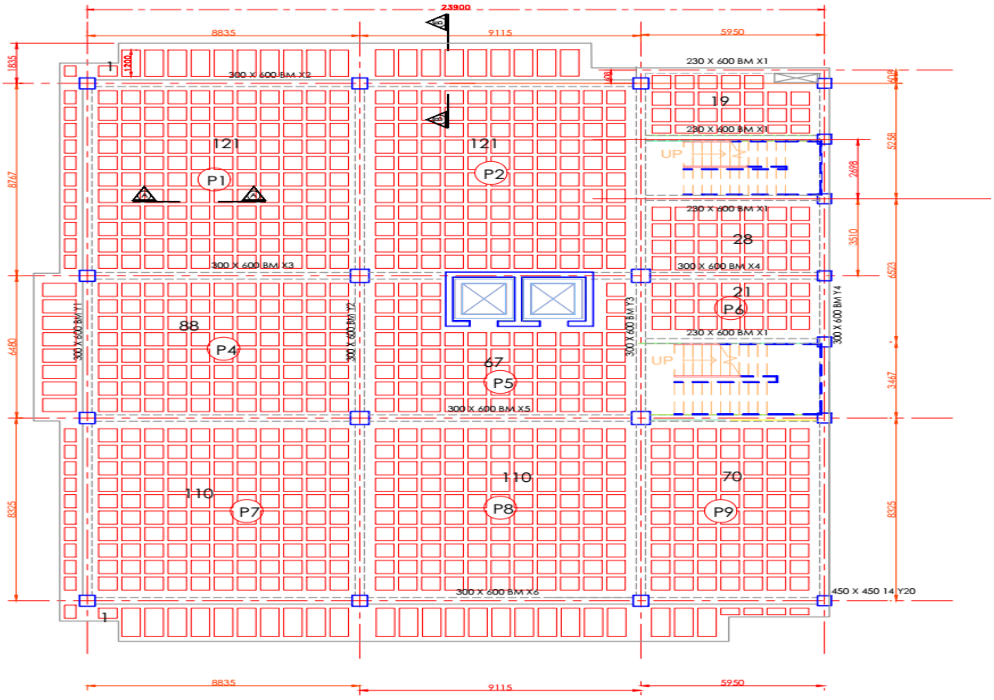


Figure 1: General Arrangement of first floor Slab Layout

3.1 Slab Panel

The slab panel shown in Figure 2 (panel 8) of the general arrangement of first floor slab was considered in this research

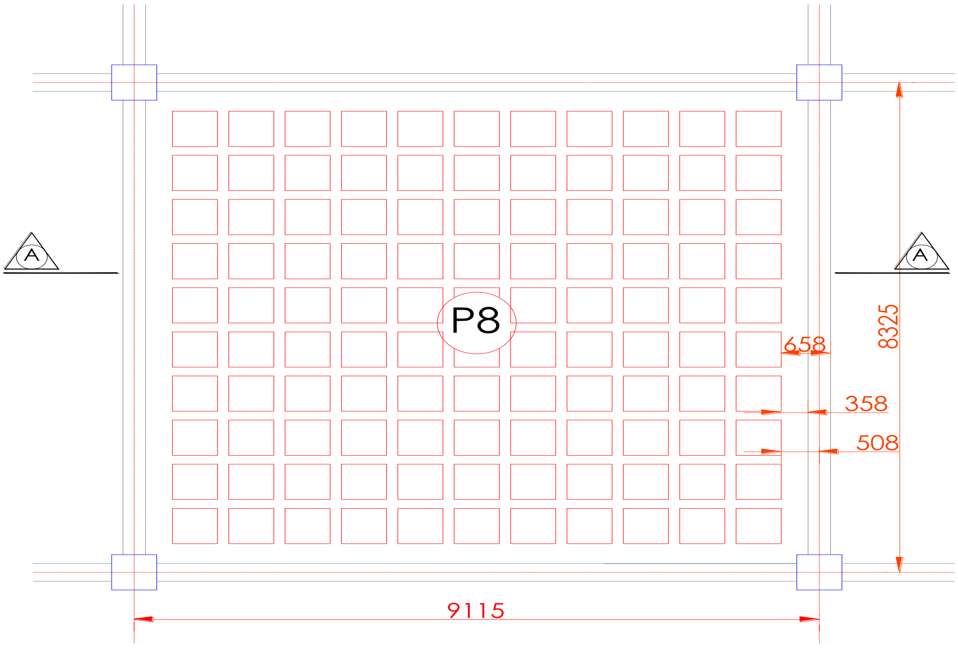


Figure 2: Slab Panel

3.2 Measured Weights

The weight of participants carrying out dancing exercise at the Bosso campus basketball court in Federal University of Technology Minna was measured and computed for the dynamic analysis.

The mean of the data is 730.547 N with a standard deviation of 93.366. The mean agrees with the data value that has been adopted in recent literatures reviewed (800 N) hence, this value will be used for this research.

3.3 Sectional properties and Loading

3.3.1 Sectional Properties

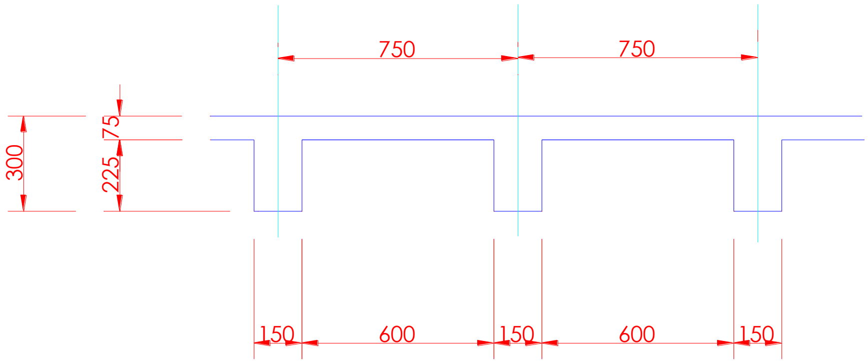
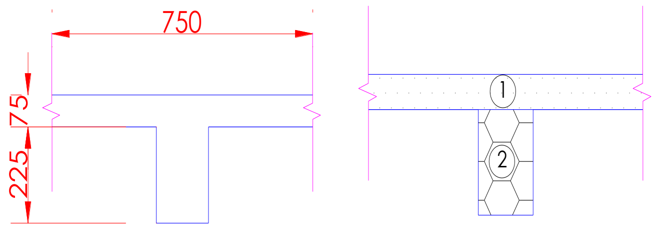


Figure 3: Section A-A of the slab panel

A. Second moment of area

The section of the T-beam shown in figure 4.a and 4.b will be used in the determination of the second moment of area.



(a) (b)

(c)

Figure 4: Section through the waffle slab

3.3.2 Loadings

Unit weight of concrete $= 24\,\mathrm{kN/m^3}$

Thickness of slab topping $= 0.075\,\mathrm{m}$

Total unfactored dead-weight of slab, $w = 24 \times 0.075 = 1.8\ \mathrm{kN/m^2}$

Finishes, say, $1\ \mathrm{kN/m^2}$

Total dead load (slab) $= 2.8\ \mathrm{kN/m^2}$

Live load $= 5\ \mathrm{kN/m^2}$ (BS 6399: part 1)

Each beam is $300\,\mathrm{mm}$ deep, with $750\,\mathrm{mm}$ flange.

Design slab load $= 1.4 \times 2.8 + 1.6 \times 5 = 11.92\ \mathrm{kN/m^2}$

Load transferred to the beam $= \frac{1}{4} w_0 {l_x}^2 = \frac{1}{4} \times 11.92 \times 0.75^2 = 1.67625\ \mathrm{kN/m^2}$

All the interior "beams" carry twice of this load, so:

$w_{sb} = 1.67625 \times 2 = 3.3525\,\text{kN}$.

Self-weight of beam $= 1.4 \times 0.75 \times 0.3 \times 0.15 \times 24 = 1.134\,\text{kN}$

Total Ultimate load $= 1.134 + 3.3525 = 4.4865\,\text{kN}$

Fixed end moment $= \frac{wl^2}{12} = 0.28\,\text{kNm}$

$\text{M} = 0.28\,\text{kNm}$

$\text{F} = \frac{4.4865}{2} = 2.24\,\text{kN}$, say, $2.5\,\text{kN}$

All interior nodes are shared by four beam elements, giving a total of 10 kN. The 10 kN point load will be applied as the out-of-plane load at the nodes of the grids in the negative y-direction.

3.4 Dynamic Analysis Result

Table 1: is an excerpt of the natural frequency.

Table 1: Natural Frequency

S/N	Frequency (rad/sec)	Frequency (Hz)
1	10.38	1.65
2	20.49	3.26
3	21.99	3.50
4	29.42	4.60
5	36.57	5.82
6	41.19	6.55
7	43.53	6.93
8	47.75	7.60
9	56.76	9.03
10	57.94	9.22
11	66.38	10.56
12	68.61	10.92
13	71.34	11.35
14	75.77	12.06
15	82.99	13.21
16	84.55	13.45
17	90.95	14.47
18	99.25	15.79

The fundamental frequency of vibration of the system is 1.65 Hz, which is within the range of 1.5 Hz to 2.8 Hz for groups involved in jumping activities. Considering the equation of step 13 in the previous chapter, the worst case is when the sine term is equal to unity. This happens when the harmonic is in phase with the loading cycle. Assuming this to be the case, the equation reduces to:

$$F = q\left[1.0 + \sum_{n=1}^{N} \alpha_n D_{\delta,n}\right] \tag{6}$$

where $D_{\delta,n}$ is the dynamic amplification factor.

The dynamic amplification factor, is given by:

$$\text{D}_{\delta,\text{n}} = \frac{1}{\sqrt{(1 - \text{n}^2\beta^2)^2 + (2\text{n}\zeta\beta)^2}} \tag{7}$$

where n is the number of the nth harmonic, β is the ratio of the applied load frequency to the natural frequency of the system and ζ is the damping ratio (1.6% is assumed).

$\beta = 1.0$, assuming the applied frequency is equal to the natural frequency.

The dynamic amplification factor is:

$$D_{\delta,1} = \frac{1}{\sqrt{(1-1^2\times 1^2)^2 + (2\times 1\times 0.016\times 1)^2}} = 31.25$$

The total load is:

$F = 0.8\,(1.0 + 1.8 \times 31.25) = 45.8\ \text{kN/m}^2$

This load is more than the imposed load used for the static design. The ultimate imposed load used was $5.0\ \times 1.6 = 8\ \text{kN/m}^2$.

As can be seen, the imposed load due to the dynamic activity is significantly higher than the static ultimate limit state design load for the floor. The floor would need to be strengthened to withstand an ultimate limit load of 45.8 kN/m^2 for aerobic activity to take place.

Reducing the span of the slab would also greatly increase the natural frequency which would in turn increase the resistance of the slab to dynamic load.

A similar analysis carried out in the SCI publication gave 20.94 kN/m^2 as the imposed load on a slab supported on 9 m and 3 m universal beams.

4.0 Conclusion and Recommendation

4.1 Conclusion

At the end of the analysis and design, it was shown that the slab could withstand the static imposed load of 8 kN/m^2 with two 20 mm high yield reinforcement steel placed per rib. However, the dynamic load due to normal jumping produced an ultimate load of 45.8 kN/m^2 which is about six times more than the ultimate imposed load.

For the slab to be suitable for aerobic activities, the span would need to be reduced and the slab stiffened. If this is not possible due to some form of restrictions, then a solid slab, or some of composite constructions may be considered.

4.2 Recommendations

The following are recommended for further research work:

i. Vibration is very critical on waffle slab as it has a serious negative effect for gymnastic activities and should be avoided

ii. The topping should completely be considered in the formation of mass and stiffness matrices

References

Wang, C.K. & Salman, C.G. (1985). Reinforced Concrete Design, Harper and Row Publishers, New York.

Melchers R. E. (1987). Structural Reliability Analysis and Prediction. *Ellis Horwood Series in Engineering, Cooper Strut*, West Sussex, England.

BS 8110-1: (1997). 'Structural use of concrete - Part 1: *Code of practice for design and construction, British Standards institution*, London.

Bachman, H. (1992). Case studies of structure with man-induced vibration. *ASCE Journal of the structural Division*, 118(3), 631-647.

Anitha, K. & Rinu, R.J. I. (2017). Design and Analysis of Grid Floor Slab, *International Journal of Pure and Applied Mathematics*, (116). 13, 109-115.

Akshay, S. R. & Riyaz, S. S. (2015). ''A review on Comparative Study of R.C.C. Waffle Slab Vis-À-Vis Prestressed Concrete Waffle Slab'', *International journal of research in Engineering, Science and Technologies (IJRESTs), 1 (8),* 121-128

Abejide, O. S. & Konitufe, C. (2015). Optimization of Flexural Prediction for Ribbed Floors in Bending, Shear and Deflection, *American Journal of Engineering Research (AJER),* 4(2), 60-71.

Optimum Particle Size of Calcium Carbide Residue Required for Effective Soil Stabilization Using Zeolite for Road Construction

Yahaya, A.U.[1a], Alhaji, M.M.[1b], Aguwa, J.I.[1c], Shehu, M.[1d], Kabiru, U.D.[2] Mahmud, M.B.[3]
[1]Department of Civil Engineering Federal University of Technology, Minna, Niger State
[2]Department of Civil Engineering Waziri Umar Federal Polytechnic Birnin Kebbi, Kebbi State
[3]Department of Civil Engineering Federal Polytechnic Bida, Niger State
Corresponding email: yasarzahra@gmail.com

Abstract
This paper examined the Optimum Particle size of CCR required for effective soil stabilization using CCR – Zeolite mixture for road construction. Preliminary examination such as particle size analysis, specific gravity test, and plasticity test were conducted to classify the soil. Compaction test was also conducted, but for the soil admixed with 10% CCR passed through different sieve sizes (0.212, 0.150, 0.100, 0.075 and 0.063mm). Essentially, UCS was the major parameter used for this research work. The results of the UCS, were taken after 7-, 14- and 28-days curing. 7-day UCS result of clay admixed with 10 % CCR passing through different sieve sizes treated with different percentages of Zeolite. The result did not indicate a defined pattern of increase in the UCS with particle size of CCR used. Strength increased with zeolite content up to 2% and thereafter decreased with zeolite content. The result did not indicate a defined pattern of increase in the UCS with particle size of CCR used. 7 day-UCS value increased from 339.51 kN/m^2 at 0 % Zeolite when treated with 10 % CCR with particle size of 0.212 mm to a maximum value of 446.21 kN/m^{2}K when treated with 10% CCR with particle size of 0.075 mm. 28day-UCS value increased from 334.66N/m at 0 % Zeolite when treated with 10 % CCR passed through 0.212 mm Sieve size to an optimum strength value of 1,430.78 kN/m^2 when 10% CCR passed through sieve 0.100mm was mixed with 2% zeolite. Hence, for road construction it is suitable to cure for a minimum of 28days at 2% zeolite mixture. However, further research such as California Bearing Ratio test, Reliability test are recommended.

Keywords: *Calcium carbide, Particle size, Road, Soil, Stabilization, Zeolite.*

1.0 Introduction
The increasing population of the world, especially developing nations has led to increase in the demand of infrastructures such as roadways, railways, housing facilities (Alhassan and Alhaji, 2020). Expansive soils swell or increase in volume in wet season on imbibition's of water and shrink or reduce in volume because evaporation in the dry seasons. This behavior of expansive soil poses a great challenge to Engineers during construction of structures such as foundations, pavement and residential and commercial buildings. In most instances, soil have to be stabilized to meet certain engineering specifications, because most of them comes with deficiencies due to geological processes the soil undergoes during formation (Jayanthi and Singh, 2016). Agricultural and industrial waste materials such rice husk, calcium carbide residue, sawdust ash, biomass ash, fly ash have widely used to completely replace cement in stabilization of clay soil (Kampala *et al*, 2013). Conventional methods of stabilizing soils to improve strength and durability of unpaved roadways have included the use of cement, lime, fly ash, and asphalt emulsion (Bartley, 2011). Although these materials are relatively inexpensive and easy to apply, they require intensive industrial processes to manufacture and have not been found to be of substantial benefit to silty, sandy soil types (Newman, *et al.*, 2004).

2.0 Materials and Method

2.1 materials

i Soil

Soil sample was collected from adjacent college of education, along Chanchaga road. Niger State. The soil was collected using disturbed sample method of disturbed at a depth of 0.8 –1.5m. The clay was air dried and pulverized as specified in BS 1377 (1992).

ii Zeolite

The zeolite used in this study was purchased from commercial market in Zaria, Kaduna State. Nigeria.

iii Calcium carbide

The calcium carbide used in this study was collected from local welders at Keteren – Gwari mechanic site, Minna, Nigeria. The sludge was then air dried crushed and sieved with the various particle sieve size (0.212, 0.150. 0.100, 0.075 and 0.063mm)

iv Water

The water used in this research work was obtained from the Civil Engineering Laboratory in Federal University of Technology, Minna Niger State

Plate I: Liquid Zeolite in a bottle & CCR

2.2 Methods

Preliminary test such as Sieve analysis, Atterberg limit and Specific gravity were carried out to standards. Other test such as compaction and unconfined compressive strength

2.2.1 XRD - Methods

The mineralogical phase characterization and estimation of the average crystallite size of the various synthesised materials were performed on a Bruker AXS D8 X-ray diffractometer system coupled with $Cu - K\alpha$ radiationof $40\ kV$ and a current of $40mA$. The λ for $K\alpha$ was $0.1541\ nm$, scanning rate was 1.5°/min, while a step width of 0.05° was used over the 2θ range.

Sample preparation

The powder samples were placed and clipped into the rectangular aluminium sample holder. The diffractograms were recorded in the 2 θ range of 20^0 - 90^0 and the phase identification was done. Other operating and instrumental conditions are shown in equation 3.1. The Scherer equation shown below was used to determine the crystal size from half height peak width.

$$d = \frac{k\lambda}{\beta cos\theta} \qquad (1)$$

Where d is crystallite size in nanometer, $K = 0.94, \lambda$ is the wavelength of the X-ray which is $0.1541nm, \theta$ is the half-diffraction angle, β is the full width at half-maximum in radian.

2.2.2 SEM - methods

The morphology and microstructure of the synthesised products was analysed using Zeiss Auriga HRSEM. HRSEM equipped with EDS was further used to determine the elemental composition of the synthesised catalysts. The method of sample preparation is described below.

Sample preparation

$0.05mg$ of the synthesised materials were sprinkled on a sample holder covered with carbon adhesive tape were and sputter coated with Au-Pd using Quorum T15OT for 5 minutes prior to analysis. The sputter coated samples were characterized using Zeiss Auriga HRSEM. The microscope was operated with electron high tension (EHT) of $5kV$ for imaging.

2.2.3 EDS – Method Sample preparation for ED's analysis

$0.05mg$ of the synthesised materials sprinkled on a sample holder covered with carbon adhesive tape and were sputter coated with Au-Pd using Quorum T15OT for 5 $minutes$ prior to analysis. The sputter coated samples were characterized using Zeiss Auriga HRSEM. The secondary electron mode is activated for imaging, and a homogeneous region on the sample identified. The microscope was operated with electron high tension (EHT) of $20kV$ for EDS and then the elemental composition of the sample was determined with EDS.

2.2.4 XRF – methods

X-ray beam were illuminates the sample, becomes excited and emits X-rays along a spectrum of wavelengths which was characterize by the atoms in the sample by absorbing energy, then ionizes and ejects electron from the lower energy levels. The ejected electrons are replaced from the outer, higher energy orbital. The X-rays were generated by cathode ray tube, filtered to produce monochromatic radiation, collimated to concentrate and directed towards the sample. The interaction of the incident rays with the sample produced constructive interference (diffracted rays). These rays were detected, processed and counted. The peak diffractions were converted to d-spacing which allows identification of minerals. The angle between the incident rays and diffractions were measured.

2.2.5 Durability test

This test was conducted for Seven days dry cure, seven days wet cure and fourteen days dry cure. The Durability was determined using the expression below;

$$D = \frac{SDC + SWC}{FDC} X100 \qquad (2)$$

Where SDC = Seven days dry curing; SWC = Seven days wet curing; FDC = Fourteen days dry curing

3.0 Result and Discussion

3.1 Summary Result

Table 1: Summary of Preliminary, Findings and Standard Requirement

S/N	Items	Preliminary Results	Standard for Subgrade	Final Results
1	Plastic Index	25.71	7 < PI < 17	12
2	Gravel	0.00	> 25.00	26
3	Sand	8.10	> 25.00	27
4	Silt clay	80.90	> 45.00	47
5	Moisture content	18.14	<16	13.5
6	MDD	1.45	1.2	2.00
7	OMC	16.40	16.00	15.45
8	UCS	197.21	700	1,400
9	Specific Gravity	2.72	3 Above	3.2

3.2 Compaction Test

In this work, compaction Test was a compulsory pre requisite conducted for 10% Calcium Carbide Residue passed through various Sieve sizes (0.212mm, 0.15mm, 0.100mm, 0.075mm and 0.063mm) to determine the Optimum Moisture content require to undertake the mixing when blending with zeolite. For sieve sizes 0.212mm, 0.15mm, 0.100mm, 0.075mm and 0.063mm their Optimum Moisture content are 19.1, 20.29, 18.86,18.25 and 18.44% respectively.

3.3 Unconfined Compressive Strength

Table 2: 7-days UCS results of clay with 10 % CCR passing

Z	0.212	0.150	0.100	0.075	0.063
0 % Zeolite	339.51	354.06	334.66	446.21	436.51
2 % Zeolite	534.92	611.11	640.21	383.10	378.31
4 % Zeolite	392.86	412.26	499.56	412.26	315.26
6 % Zeolite	291.00	334.65	242.50	291.00	378.31

Result in Table 1 is the 7-day UCS result of clay admixed with 10 % CCR passing through different sieve sizes treated with different percentages of Zeolite. The result did not indicate a defined pattern of increase with particle size of CCR used. Strength increased with zeolite content up to 2 % and thereafter decreased with zeolite content. 7 day-UCS value increased from 339.51kN/m^2 at 0% Zeolite when treated with 10 % CCR passed through 0.212 mm Sieve size to 354.06 kN/m^2 when material passed through on the 0.150mm sieve sizes were used and declined to a value of 334.66kN//m^2 when treated with particle sizes of 0.100mm and increased to a value of 446.21kN/m^2 when treated with materials retained on the 0.075 mm sieve size and declined to the value of 436.5kN/m^2 when treated with particles passing the 0.063 mm sieve size.

Table 2:14-days UCS results of clay admixed with 10 % CCR

Z	0.212	0.150	0.100	0.075	0.063
0 % Zeolite	679.01	397.71	388.01	761.46	388.01
2 % Zeolite	630.51	921.51	606.26	1,280.42	1,091.26
4 % Zeolite	485.01	557.76	392.86	1,042.77	1,031.22
6 % Zeolite	475.31	334.66	509.26	572.31	642.48

Result in Table 2 is the 14-days UCS result of clay admixed with 10 % CCR passing through different sieve sizes treated with different percentages of Zeolite. The result did not indicate a defined pattern of increase with particle size of CCR used. Strength increased with zeolite content up to 2 % and thereafter decreased with zeolite content. 14 day-UCS value decreased from 679.01 kN/m^2 at 0 % Zeolite when treated with 10 % CCR passed through 0.212 mm Sieve size to 397.71 kN/m^2 when material passed through 0.150mm sieve sizes were used and declined to a value of 388.01 kN/m^2 when treated with particle sizes of 0.100mm and increased to a value of 761.46kN/m^2 when treated with materials passed through 0.075 mm sieve size and declined to the value of 388.01kN/mm^2 when treated with materials passed through 0.063 mm sieve size.

Table 3: 28-days UCS results of clay admixed with 10 % CCR passing

Z	0.212	0.150	0.100	0.075	0.063
0 % Zeolite	334.66	630.51	679.01	1,091.27	509.26
2 % Zeolite	800.26	1,212.52	1,430.78	1,111.52	1,057.32
4 % Zeolite	737.21	1,367.72	1,164.02	1,018.52	970.02
6 % Zeolite	974.87	606.26	970.02	858.47	1,003.93

Result in Table 3 is the 28-days UCS result of clay admixed with 10 % CCR passing through different sieve sizes treated with different percentages of Zeolite. The result indicates an increase in strength with decrease in the particle size of CCR used. Strength increased with zeolite content up to 2 % and thereafter decreased with zeolite content. 28day-UCS value increased from 334.66 kN/m^2 at 0 % Zeolite when treated with 10 % CCR passed through 0.212 mm Sieve size to 630.51 kN/m^2 when material passed through 0.150mm sieve sizes were used raised to a value of 679.01kN/m^2 when treated with particle sizes of 0.100mm and increased to a value of 1,091.27 kN/m^2 when treated with materials retained on the 0.075 mm sieve size and declined to the value of 509.26 kN/m^2 when treated with particles passing the 0.063 mm sieve size.

3.4X- ray fluoresces (XRF)

Table 4: Summary of XRF Results

Sample	Clay	CCR	Zeolite
Fe_2O_3	12.33	0.27	0.013

MnO	0.16	0	0
CrO_3	0.03	0	0
V_2O_5	0.06	0	0
TiO_2	1.85	0.05	0.04
CaO	1.47	62.55	0.38
K_2O	0.26	0.11	0.27
P_2O_5	0.05	0.08	0.04
SiO_2	56.22	4.44	31.7
Al_2O_3	15.52	1.30	27.18
MgO	1.69	0.74	1.29
Na_2O	0.7	0	19.62
LOI	9.27	29.62	20.28

The Table 4 above is the summary of the XRF results obtained for the three major materials used for this research work are Calcium Carbide residue, Clay and Zeolite. The highest representation in the clay is SiO2 which is 56.22 while in the Calcium Carbide Residue is CaO which is 62.55 while in the Zeolite the highest is SiO2 which is also 31.7. MnO, CrO_3 and V_2O_5 are not represented in the Calcium Carbide and the Zeolite but they in very small quantum in the original clay soil. Na_2O is not represented in the Calcium Carbide Residue while in the zeolite and clay its present in 19.62 and 0.76 respectively

XRD – Discussion of results

Figure 1 – 4 represent XRD- graph of four typical samples showing the mineral composition and their phases. Figure 1 is for Natural clay soil from the site; the graph shows that Quatrz (Q) appears to be dominance and of higher counts than any other minerals present in the sample. No trace of Calcite and Edenite was found in this sample. Other minerals such as Albite, Kaolinite and Anorthite are present in a small scale. Figure 2 is for Clay + 10% CCR passed sieve 0.100 graph showing clearly that addition CCR to the mixture brought about the introduction of two other minerals (Calcite and Edenite).

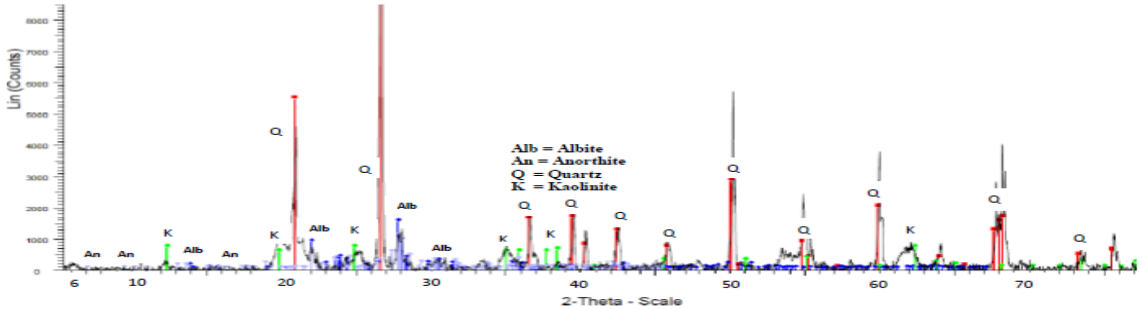


Figure 1: XRD – Natural Clay

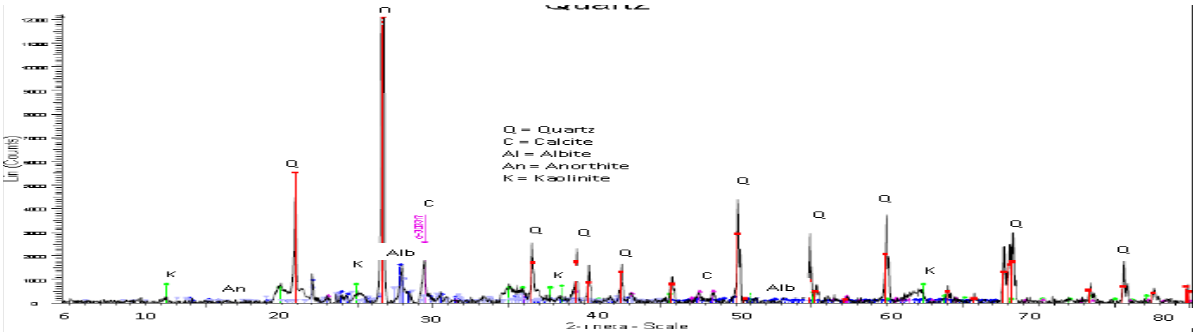


Figure 2: XRD – Clay + 10% CCR passed sieve 0.100 + 2%

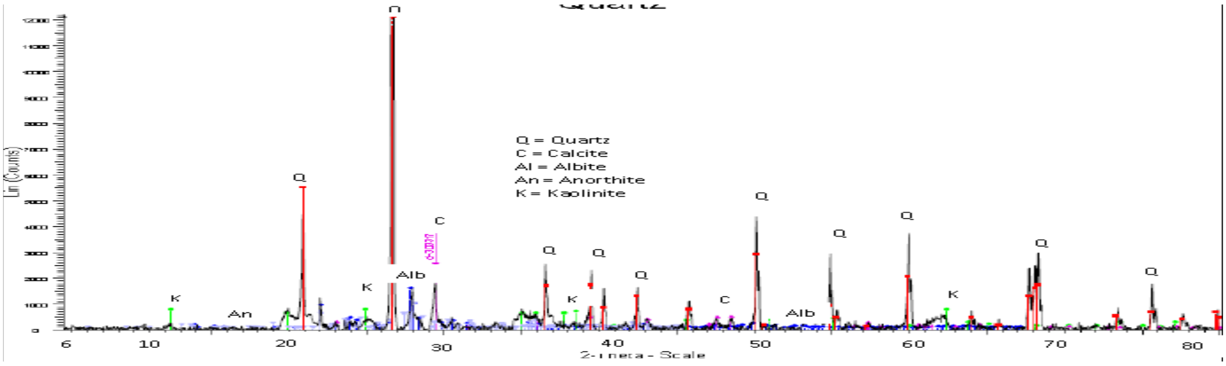


Figure 3: XRD – Clay + 10% CCR passed sieve 0.075 + 2% Zeolite

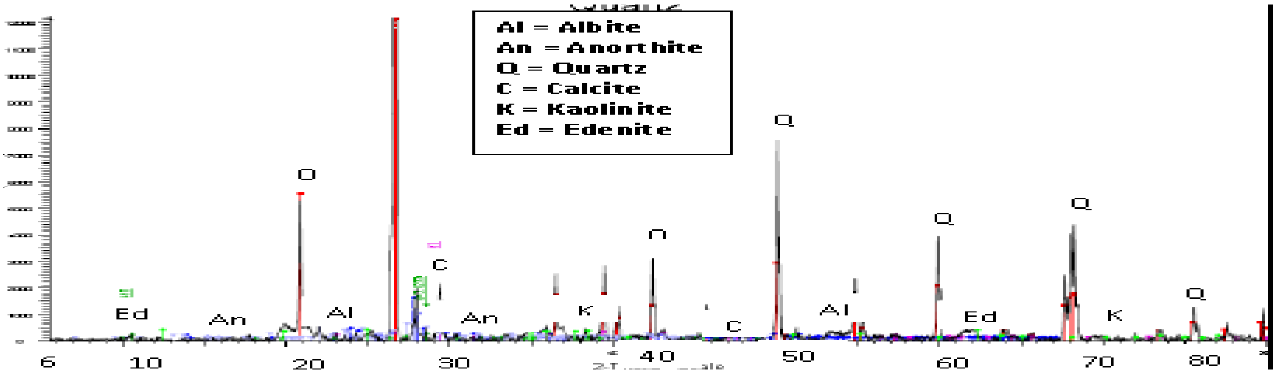


Figure 4: XRD – Clay + 10% CCR passed sieve 0.100

3.5 EDS Results and Discussion

The Table summarizes EDS –Result for only four samples examined for this work. They are Ordinary Clay, Clay admixed with 10% CCR passed sieve 0.100mm and 2% Zeolite, Clay admixed with only 10% CCR passed sieve 0.100mm and Clay admixed with 10% CCR passed through sieve 0.0075 and 2% zeolite represented as A, L, N and M respectively. All the samples have predominantly high Oxygen (O) but highest in sample M. Sample A contained Carbon (C) and Manganese (Mn) at 7.66% and 0.79% respectively. But, are both not contained in sample L, N and M.

These results are best interpreted by direct observation and physical deductions from the morphology presented by the SEM. Figure 4.5 depicted the morphology of a Natural clay soil which depicted the following characteristics

Table 5: Summary of EDS – Results

S/N	Element	Natural Clay (A)	Clay with 10% CCR passed through sieve 0.100mm admixed with 2% zeolite (L)	Clay with 10% CCR passed through sieve 0.100mm no zeolite (N)	Clay with 10% CCR passed through sieve 0.075mm admixed with 2% zeolite (M)
1	C	7.66	NIL	NIL	NIL
2	O	39.67	50.7	51.92	56.77
3	Na	0.27	0.5	NIL	0.84
4	Mg	0.75	0.49	0.62	0.65
5	Al	10.79	10.33	7.72	8.4
6	Si	21.1	15.69	14.98	16.85
7	Ca	0.84	16.47	17.79	11.06
8	Ti	1.5	0.78	0.79	0.53
9	Mn	0.79	NIL	NIL	NIL

10	Fe	16.64	5.04	6.19	4.89
	TOTAL	100	100	100	100

3.6 Durability Results and Discussion

Table 6: Summary of EDS - Results

Zeolite	0.212	0.150	0.100	0.075	0.063
0 % Zeolite	65	65	84	94	80
2 % Zeolite	68	70	98	95	94
4 % Zeolite	75	75	95	94	87
6 % Zeolite	72	80	95	87	94

4.0 Conclusion

Essentially, UCS was the major parameter used for this research work. The results of the UCS, were Conceived in three categories; 7-, 14- and 28-days curing. The result did not indicate a defined pattern of increase with particle size of CCR used. Strength increased with zeolite content up to 2 % and thereafter decreased with zeolite content. The result indicates an increase in strength with decrease in the particle size of CCR used. Strength increased with zeolite content up to 2 % and thereafter decreased with zeolite content. The optimum strength was 1,430.78 kN/m^2 which was achieved when 10% CCR passed through sieve 0.100mm admixed with 2% zeolite content. The durability test conducted reveals that most of the samples that passed UCS test as sub- grade material for road pavement construction equally passed the durability test.

References

Alhassan and Alhaji (2020) Effect of Zeolite on Unconfined Compressive Strength of Cement Stabilized Clay Soil as a Construction Material, *2nd International Civil Engineering Conference, Civil Engineering Department,* Federal University of Technology, Minna, Nigeria, Pp 301-311Soil stabilization

A. Kampala, C. Suksiripattanapong, S. Horpibulsuk (2014) Strength improvement of lateritic soil by calcium carbide residue for pavement applications. *Proc. of Inter. Conf. ACESD.*, pp. 703-709

A. Kampala, S. Horpibulsuk (2013). Engineering properties of calcium carbide residue stabilized silty clay, *J. Mater. Civil Eng. ASCE, 25 (5)* (2013), pp. 632-644

A. Kampala, S. Horpibulsuk, N. Prongmanee, A. Chinkulkijniwat (2014). Influence of wet-dry cycles on compressive strength of calcium carbide residue-fly ash stabilized clayJ. Mater. Civil Eng. ASCE, 24 (1) pp. 633-643

Bartley, P. A., (2011). *Experimental Investigation of the Sand-Stabilization Potential of a Plant Derived Biomass.* M.S. Thesis Kansas State University.

BS 1377, (1992). Soil for civil engineering purpose-Classification test. British Standard Institution, London. UK.

Jayanthi and Singh (2016). Cementing material from calcium carbide residue-rice hush ash.*J. Mater. Civil. Eng. ASCE, 15* (5) pp. 470-475

Newman, *et al.*, 2004 Soil stabilization by calcium carbide residue and fly ash. *J. Mater. Civil Eng. ASCE, 24 (2) (2012),* pp. 184-193

Assessment of the Performance of Sandcrete Blocks Produced by Partially Replacing Sand with Coal Bottom Ash as a Fine Aggregate

Ojutiku, M. O.[1a], Sadiku, S.[1b], Oritola, S. F.[1c], Shehu, M.[1d], Oglekwu, F. O.[1e], Adamu, H. N.[1f]

[1]*Department of Civil Engineering, Federal University of Technology, Minna, Niger State, Nigeria,*
[a]*mukhtarojutiku2012@gmail.com;* [b]*salawu.sadiku@futminna.edu.ng;* [c]*sfaoritola@futminna.edu.ng;*
[d]*moh.shehu@futminna.edu.ng;* [e]*francisoglekwu@gmail.com;* [f] *h.adamu@futminna.edu.ng*

Abstract

This paper describes the results of an experimental investigation into the assessment of the performance of Sandcrete blocks produced by partially replacing sand with coal bottom ash as fine aggregate. The physical properties of coal bottom ash and sand were carried out in accordance with BS 1377-9 (1990). Sandcrete blocks were produced using hand mould in 0, 10, 20, 30, 40 and 50% replacement levels of sand with the coal bottom ash using cement-sand ratio of 1:6. They were cured at the ages of 7, 14, 21, 28 days and were then subjected to compressive strength tests. Sieve analysis test showed a very similar particle size distribution between sand and coal bottom ash. It was found out that the optimum replacement level was achieved at 20% and the 28-day compressive strength at this level was 3.11N/mm^2 which is greater than the minimum strength of 2.8N/mm^2 specified by BS 6073-2 (2008). Also, there was a decrease in the weight of the blocks with an increase in coal bottom ash content; this indicates the suitability of using coal bottom ash as a lightweight material in Sandcrete block production.

Keyword: Sand, Block, Coal Bottom Ash, Strength, Aggregate

1.0 Introduction

Sandcrete blocks have been the predominant walling material in both residential and commercial buildings in West Africa for over fifty years, (Onwuka *et al.*, 2013). They are used extensively due to the availability of raw materials used in its production (Yusuf *et al.*, 2017). Sandcrete blocks are produced with a mixture of cement and sand with a varying percentage of water. In Nigeria today, the production of sandcrete blocks requires a significant amount of river sand. This river sand is sourced constantly from various mines and this constant mining has an adverse effect as it leads to depletion of this material and the deterioration of the environment. The need to search for an alternative source of fine aggregate, which will be suitable for production of masonry blocks, forms the background of using coal bottom ash as an alternative to sand for this study.

Coal bottom ash is a residue, among others, obtained from the combustion of coal during thermal power generation. These residues are generally referred to as coal combustion products (CCPs). Other CCPs include fly ash, boiler slag, flue gas desulfurization (FGD) and gypsum (Kim and Lee, 2014). The properties of these materials were not studied or evaluated seriously and nearly all the CCPs were landfilled (Ramme-Tharaniyil, 2000). The landfilling of these CCPs were later found to pose a great risk to human health and the environment as it spreads hazardous components, contaminates adjacent soil and underground water (Khan and Ganesh, 2016). In the course of time, the cementitous and pozzolanic properties of fly ash were recognized and studied by several individuals and institutions. The products were tested to understand their physical properties, chemical properties and suitability as a construction material.

Several experiments have also been done on application of coal bottom ash in construction. These works focused primarily on concrete production. A research work carried out by Khan and Ganesh (2016) on the effect of coal bottom ash on the mechanical and durability of concrete showed that with an increase in the amount of coal bottom ash, early age strength is less compared to control mix, but as age increases, they showed good improvement in strength due to pozzolanic reaction and concluded that 10% replacement of cement with coal bottom ash is economical and lesser amount of CO_2 is emitted. Kim and Lee (2011) investigated the effect of fine and coarse bottom ash on the compressive strength of concrete at 7- and 28-days age of curing. They observed that the compressive strengths were not significantly affected by the replacements of fine aggregate with bottom ash. The objective of this work is to investigate the effect of partial replacement of sand with coal bottom ash on the compressive strength and density of masonry blocks.

2.0 Methodology

2.1 Materials

The materials described below were used for this study.

2.1.1 Coal bottom ash

The Coal Bottom Ash (CBA) was acquired from Unicane Industries limited located at Jamata village along Lokoja expressway in Kogi state, Nigeria. The CBA was sieved, and the aggregate used were those that passed through sieve with aperture 4.75mm. The aggregate was clean, sharp, and free from clay, loam, dirt or organic matters (NIS 87:2004).

Plate I: Coal Bottom Ash

2.1.2 Fine aggregate

The aggregate was obtained from a river at Gidan Mangoro along Bida-Minna Road in Minna, Niger state. The fine aggregate was clean, sharp, and free from clay, loam and any organic or chemical matter (NIS 87:2004). It was also well graded to conform to the requirement in BS 882:1992, Aggregates from natural sources for concrete.

2.1.3 Cement

The cement used in this study is the Ordinary Portland Cement (OPC). The cement used was Dangote 3x cement produced in accordance with NIS 87:2004 Part 1, classified as CEM 1 of the standard and it was purchased from a cement depot at Gidan Kwano area, opposite the main gate of the Federal University of Technology, Minna, Niger State.

2.1.4 Water

The water used for mixing and curing the block samples was potable water obtained from the tap at civil engineering laboratory, Federal University of Technology, Minna, Niger State. It was properly examined to ensure that it was clean, fit for drinking and free from deleterious materials such as clay, silt, alkali, acids and organic materials.

2.2 Physical Properties

In this study, laboratory tests on the sand and coal bottom ash to determine their respective physical properties. The properties investigated include the particle size distribution, specific gravity, bulk density and moisture content. These investigations were done in accordance with BS 1377-9 (1990).

2.3 Block Manufacturing

Seventy-two (72) hollow blocks with the size of 450mm x 225mm x 150mm were produced manually with the mix ratio 1:6; cement: sand on volume basis. This was done in the civil engineering laboratory of Federal University of Technology, Minna. Sand used in the cement-sand mixture was replaced with coal bottom ash at 0, 10, 20, 30, 40 and 50% replacement level by weight. Water was added to the mixture while maintaining 0.5 water cement ratio. The blocks produced were then cured for 7, 14, 21 and 28 days respectively by spraying method.

2.4 Compressive Strength Test

Compressive strength test on the produced block samples were carried out. For each curing day, eighteen (18) numbers of the produced blocks were subjected to compressive strength test to determine the load that will lead to failure of the block samples. A manual compressive strength testing machine in the Laboratory of Building department, Federal University of Technology, Minna, Nigeria was used. For each replacement level, three (3) blocks were tested, and the average compressive strength was obtained by getting the average of the measurements for three blocks.

3.0 Results and Discussions

3.1 Physical Properties

Figure 1 shows the particle size distribution that was obtained from the sieve analysis test for sand and coal bottom ash. The result revealed that both CBA and sand have almost similar trend in the distribution of particle size at similar percentages. The percentage passing for selected sieves was lying between 10% to 80% for CBA and 0% to 90% for sand. This complied with the grading limit of fine aggregate in zone 4 in accordance with NIS 87:2004, therefore the aggregate is suitable for block making. However, the curve for the sand is steep, this indicates that the aggregate contains particle of almost same size which in turn means the soil is poorly graded.

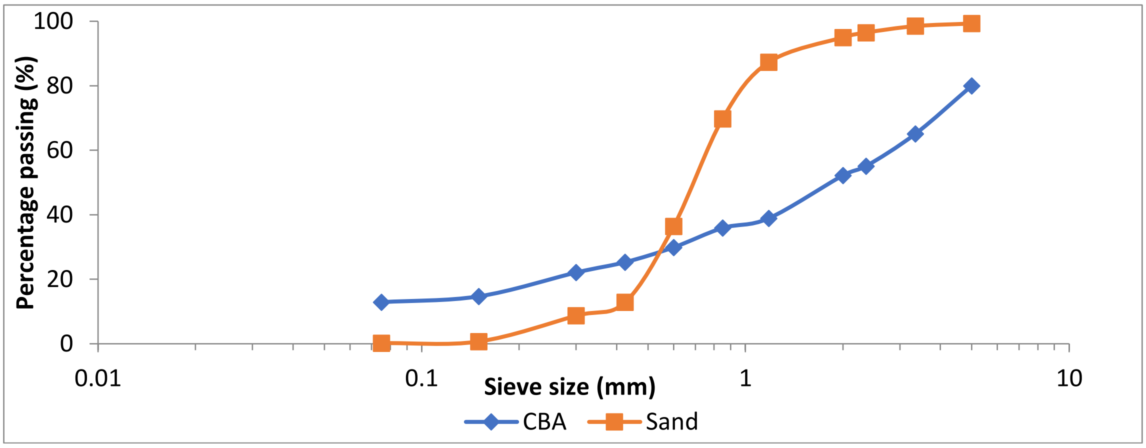


Figure 1: Particle size distribution of sand and coal bottom ash

The results of the physical properties of the sand and coal bottom ash are presented in Table 1 below. The specific gravity for coal bottom ash and sand were found to be 2.55 and 2.70 respectively and is presented in Table 1.

Table 1: Summary of the properties of sand and coal bottom ash (CBA) used in the study.

Physical Test	Sand	Coal bottom ash
Specific gravity	2.70	2.55
Bulk density (kg/m3)	1606.06	842.80
Moisture content (%)	5.04	23.83

The value obtained for sand falls within the limit of 2.6 and 2.7 for natural aggregates as prescribed by BS 812 part 109: 1990, while the value obtained for coal bottom ash just falls by 0.05 below the limit.

The mean bulk density of the sand was found to be 1606.06kg/m^3 which fall within the standard range of 1300 – 1800kg/m^3 in accordance with BS 812: Part 109 (1990). The mean bulk density of coal bottom ash was found to be 842.80kg/m^3. This shows that coal bottom ash is less dense than sand and is loosely packed. The density depends on how densely the aggregates are packed.

The average moisture content of sand as shown in Table 1 is 5.04% which falls between the ranges of 5 to 15% (BS 812: Part 109, 1990). The average moisture content of CBA obtained is 23.83%. This falls beyond the range stated by BS 812: Part 109, (1990). This implies that the CBA will absorb less amount of water from the mixture than the sand aggregate. The moisture content of a soil is dependent on the void ratio of the soil; thus, this value is indicative of the void spaces present in the soil and also the specific gravity.

3.2 Chemical Properties of CBA

The result of the chemical property of the coal bottom ash is presented in Table 2 below. From the investigation, the cumulative combination of SiO2 + Al2O3 + Fe2O3 for the CBA used in this study is 63.25%, making the CBA pass the minimum requirement of 50% for C class pozzolana. However, the CBA contains 38.81% of SiO2 and 10.79% of alkali making the CBA unsuitable be classified into any pozzolana class.

Table 2: Chemical properties of coal bottom ash used in the study.

Description	N Class (%)	F Class (%)	C Class (%)	CBA sample (%)
SiO_2	-	54.90	39.90	38.81
$SiO_2 + Al_2O_3 + Fe_2O_3$	70.00	70.00	50.00	63.25
SO_3	4.00	5.00	5.00	17.79
Water Content	3.00	3.00	3.00	23.83
Incandescent lost (LOI)	10.00	12.00	6.00	-
Alkali	1.50	1.50	1.5.00	10.79
Pozzolan activity with 7 days lime	56.25	56.25	-	-

3.3 Compressive Strength Test Results

The highest value of compressive strength was obtained for the block made with zero percentage of coal bottom ash (control sample). However, the result also shows that the 20% coal bottom ash replacement provides the greatest compressive strength among the blocks manufactured with the bottom ash. At this percentage, the 28-day compressive strength was 3.11N/mm2 which is greater than the minimum required value of 2.8N/mm2 (BS 6073: Part 2: 2008). The 10% replacement has shown a 28-day compressive strength of about 2.85N/mm2 which is also greater than the minimum required value. This shows that the optimum replacement level of coal bottom ash is 20% of sand. The compressive strength then decreased gradually at 30, 40 and 50% partial replacements.

The results for the average compressive strength test of the block samples are shown in Figure 2.

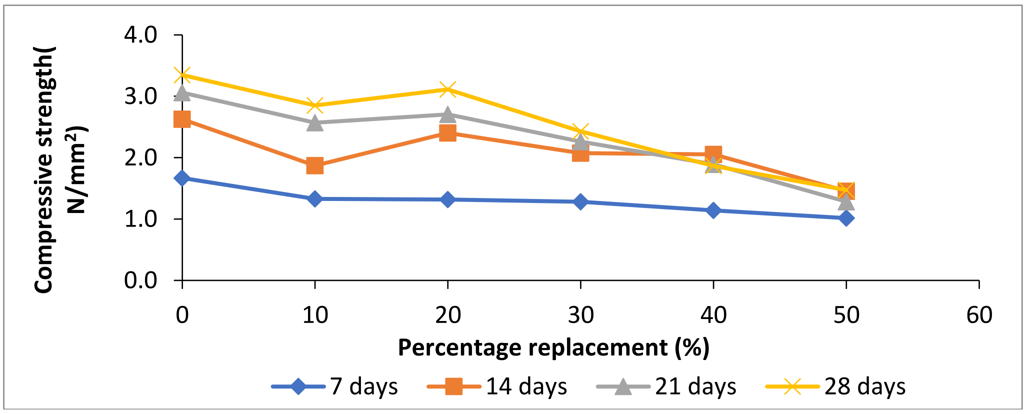


Figure 2: *Average compressive strength of sandcrete blocks for different coal bottom ash replacement levels.*

3.4 Dry density of block samples

The result shows a decrease in the density of the block samples with an increase in coal bottom ash replacement and curing age. This indicates that the coal bottom ash can be used as a lightweight material to produce blocks with acceptable strength. This will in turn reduce the weight of buildings.

The relationship between percentage replacement of sand with coal bottom ash and dry density of block sample is presented in Figure 3.

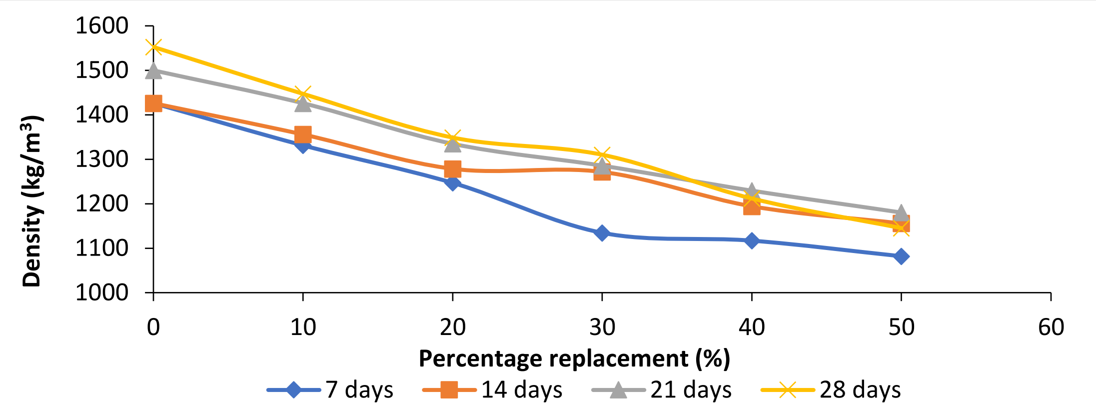


***Figure 3**: Relationship between dry density of block and percentage replacement of coal bottom ash*

4.0 Conclusion

The CBA used in this research contains 38.81% of SiO2 and 10.79% of alkali making it unsuitable be classified into any pozzolana class The block produced from coal bottom ash at 10 to 20% replacement level shows higher compressive strength than the required standard minimum value, this indicates that the block can be used to construct load bearing walls. In addition, the block produced from coal bottom ash is very much lighter than the blocks produced from sand, thus it can be used as a lightweight walling material.

References

BS 812: Part 109 (1990). *Testing aggregates. Methods for determination of moisture content*. British Standard Institute, London U.K

BS 882 (1992): *Specification for Aggregates from Natural Sources for Concrete*. British Standards Institution, London.

BS 1377 (1990) *Methods of Testing Soil for Civil Engineering Purposes*. British Standard Institute, London, U.K

BS 6073: Part 2 (2008). *Method for specifying precast concrete masonry units*. British Standard Institute, London, U.K

Khan, R.A. and Ganesh, A. (2016). The effect of coal bottom ash (CBA) on mechanical and durability characteristics of concrete. *Journal of Building Materials and Structures*; 3(1), pp. 31 – 42

Kim, H. K. and Lee, H. K. (2015). Coal Bottom Ash in Field of Civil Engineering: A Review of Advanced Application and Environmental Consideration. *Korean Society of Civil Engineers (KSCE) Journal of Civil Engineering*, 19(6), pp. 1802-1818.

Kim, H.K. and Lee, H.K. (2011). Use of power plant bottom ash as fine and coarse aggregates in high-strength concrete. *Journal of Construction and Building Materials*; 25(2), pp. 1115–1122.

Nigeria Industrial Standard, NIS 87:2004. *Standard for sandcrete blocks*. Standard Organization of Nigeria Lagos, Nigeria.

Onwuka, D. O., Osadebe, N. N. and Okere, C. E. (2013). Structural Characteristics of sandcrete Blocks produced in South- East Nigeria. *Journal of Innovative Research in Engineering and Sciences*,4(3), pp. 483- 490

Ramme-Tharaniyil (2013). *We Energies Coal Combustion Products Utilization Handbook. 3rd Edition.* We Energies Limited, United States of America

Yusuf, A., Aminulai, H.O., Abdullahi, A., Bala, A. and Alalade, A.I. (2017). Dimensional Compliance and Compressive Strength of Sandcrete Hollow Blocks Produced in Minna Metropolis. *Proceedings of the 2nd International Engineering Conference, Held at Federal University of Technology, Minna, Niger State, Nigeria.*

Biogenic Possibilities of Improving Mortar Strength Using Effective Microorganisms

Olukotun, N[1,2], Abdul, C.I.[2,3], Ekule, A.[4]&Abdullahi, N.A.[4]

[1,2]omolayo.olukotun@graduate.utm.my, [3,4]ileanwa@graduate.utm.my, [4]ekuleadejoh@yahoo.com; [4]arcnuhu@gmail.com

[1]School of Civil Engineering, Faculty of Engineering, Universiti Teknologi Malaysia, 81310 Johor, Malaysia

[2]Department of Building Technology, Kogi State Polytechnic, Lokoja, Nigeria

[3]School of Architecture Programmes, Faculty of Built Environment and Surveying, UniversitiTeknologi, Malaysia, 81310, Johor, Malaysia

[4]Department of Architectural Technology, Kogi State Polytechnic, Lokoja, Nigeria.

Correspondence email: ileanwa@graduate.utm.my

Abstract

The demand for durable and sustainable mortars rising due to the daily increase in global greenhouse gas (GHG) emissions and global warming.This study proposes the use of effective microorganisms (EM) as an additive to propel modifications within the mortar matrix. This research used two types of EM to replace water at different concentrations. EM was used to replace water at 10% and 15% replacement levels. Fresh and hardened properties of EM-based mortar were obtained. Flow tests show thatthe addition of EM increased mortar flow. Similarly, the compressive strength increased up to 20% above control. This study shows that EM can significantly improve the strength of mortar.

Keywords: *Effective microorganisms; Durability; mortar; compressive strength; workability*.

Introduction

Mortar is one of the most used materials worldwide, alongside concrete. Mortar is an essential composite for bedding and jointing brickwork, plastering and rendering. Globally, rapid infrastructural growth has increased the demand for cement mortar. Unfortunately, there are no exact measures of the quantity of mortar used worldwide annually. However, about 4 billion tons of cement are produced annually (Wang, 2019) and a ton of cement produced results in the release of about a ton of carbon dioxide (CO_2), which contributes to global warming (Chen et al, 2010). This large volume of cement is majorly utilized for concrete and mortar. Thus, it is necessary to ensure the sustainable usage of mortar by reducing the use of cement while its toughness is maintained. Good mortar should optimally achieve functionality, strength and reliability throughout its entire design life. This reduces the probability of reconstruction and thus reducescement usage and global warming.

To achieve high-performance mortar, several chemical additives have been produced (. Mohammed *et al*, 2017). Chemical admixtures are added to concrete to improve its workability, accelerate or retard setting times, promote air entrainment, and improve its mechanical and durability properties. The most common admixtures are calcium lignosulphonates (Danner et al,2015) calcium nitrate (Kumar et al,2018), gypsum (Guo & Shi, 2008), and silica fume (Hemavathi et al,2019; Giner et al,2011). However, certain disadvantages associated with these chemical additives (such as cost, sudden slump drop, bleeding, colouration, and rapid shrinkage) do not permit sustained use. Studies have also shown that the production of chemical admixtures contributes immensely to global warming (Latawiec et al,2018). Chemical admixtures emit as much CO_2 as cement production (Irfan, 2011). In addition to replacing cement with renewable materials, cheap natural additives can be added to mortar to improve and promote green construction (Bertron,2015; Seifan et al,2016; Wang et al,2016).

One such readily available and cheap additive is microorganisms. Microorganisms are found wherever there is sufficient space, nutrients, and water (Basha *et al*,2018). Thus, their availability is guaranteed. They can survive in concrete due to their capacity to live under very severe conditions and adapt to different environments (Hutkins&Nannen,1993; Padan,2005; Papadimitriou et al,2016). In this present research, EM was used as an additive to improve the properties of mortar.

Materials

Materials used in this study were cement, natural fine aggregate (NFA), EM and water. Ordinary Portland cement (OPC) of 42.5R grade and specific gravity of 3.14according to ASTM C 150 (ASTM,2004) was used. NFA of maximum aggregate size 4.75mm was used. EM was included as a liquid additive to modify the properties of mortar. Tap water was used for mixing and curing mortar specimens.

Characteristics of Fine Aggregate

The physical and chemical properties of the fine aggregate were measured according to ASTM C128 (ASTM,2004) and presented in Table 1 and Table 2.

Table 1: *Physical properties of fine aggregate*

S/N	Physical properties	Sand
1	Specific gravity	2.62
2	Water absorption (%)	2.0

Table 2: *Chemical properties showing major oxides of NFA*

S/N	Chemical properties	NFA
1	Silica	93.45
2	Alumina	3.55
3	Magnesium oxide	1.3
4	Iron oxide	1.2
5	Calcium oxide	0.5

Characteristics of Effective Microorganisms

Effective microorganisms (EM) are a solution containing predominantly lactic acid bacteria (LAB), photosynthetic bacteria (PSB) and yeast. EM used in this study is EM1 and EM2. Molasses was added as a nutrient source for the microorganisms. EM1 contains mainly LAB and yeast, while EM2 contains PSB predominantly. Figure 1 depicts the pictorial representation of the constituents of EM used in this study

Table 3 shows the physical characteristics of EM. EM1 is a brown-coloured solution with a mild smell, while EM2 is a reddish-brown-coloured liquid with a pungent smell. On the other hand, Molasses is a thick dark brown solution with an odourless smell.

Table 3: Physical Properties of Effective Microorganisms

EM Type	EM1	EM2
Colour	Brown	Reddish brown
Smell	Mild	Pungent
PH	3.5	3.5

Figures 1 (a) – (c) depicts the morphology of EM1, EM2 and molasses, respectively. EM1 and EM2 contain dormant spores, which are less active till molasses are added to activate them. Identifying constituents that makeup EM1 and EM2 was necessary to ascertain their microbe type. This was carried out by laboratory culture.

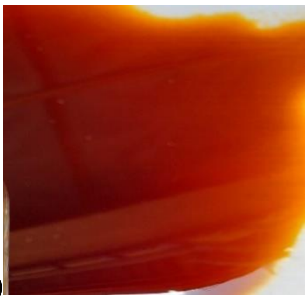
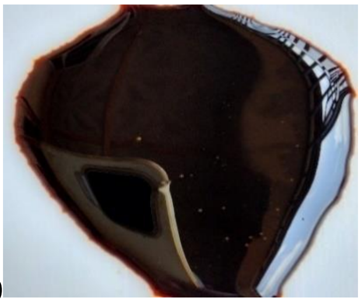
(a)  (b)  (c) 

Figure 1: Constituents of EM Solution (a) EM1 (b) EM2 (c) Molasses

The cell population of the bacteria present were ascertained, as seen in Table 4. This is useful as it will provide ample information about the life span of the microorganism after incorporating it in cement mortar.

Table 4:Cell Population of Bacteria in EM1 and EM2

Bacteria type	Concentration (CFU/g)	Concentration (CFU/g)
LAB	$1.8x10^8$	ND
Yeast	$1.0x10^9$	ND
Actinomycetes	$2x10^2$	$2x10^2$
PSB	ND	$1x10^9$

ND = Non detected

The chemical composition of EM is shown in Table 5. This was carried out by XRF analysis. Table 5 shows that EM1 contains a higher amount of Si, Cl, Al, Ca, K and S than EM2.

Table 5: Chemical Composition of EM

Component	EM1(ppm)	EM2 (ppm)
Mg	28200	374000
Si	194000	126000
Cl	433000	10200
Al	37300	116000
Ca	116000	86800
K	87400	9420
S	55300	36000

Mix Proportioning and Sample Preparation

Five different mixes were prepared for this study. All mortar specimens were prepared using cement to fine aggregate volume ratio of 1:3. The control mix was without EM, while the other samples had EM of different types and concentrations. EM1M designates EM1 mortars, while EM2M designates EM2 mortars. The *w/c* ratio applied in this study is 0.55. Table 6 shows the mix proportions of the mortar used in this study. For the efficient activity of effective microorganisms, EM must be activated. Activated EM consists of a mixture of EM, Molasses and water. The dominant spores become very active when molasses is added. To study the effect of EM on the strength development of mortar, two concentrations of EM were used (10% and 15%). EM1MC1 represent EM1 at a concentration of 10%, while EM1MC2represent EM1 at a concentration of 15%. Likewise, EM2MC1 represent EM2 at a concentration of 10%, while EM2MC2 represent EM2 at a concentration of 15%. To produce the different mortar mixes, activated EM was used to replace mixing water.

Table 6: *Mix proportions of constituents for 1m^3 of mortar*

Mix	Designation	Cement (kg)	Sand (kg)	EM type	Water (kg)	*w/c*
M1	C	530	1590	-	291.5	0.55
M2	EM1MC1	530	1590	EM1	291.5	0.55
M3	EM2MC2	530	1590	EM2	291.5	0.55
M4	EM1MC1	530	1590	EM1	291.5	0.55
M5	EM2MC2	530	1590	EM2	291.5	0.55

Testing Procedures

Tests to evaluate microorganisms' effects include fresh and hardened properties. The fresh property considered in this study is workability, and this was performed through a mortar flow test following ASTM C1437guidelines (ASTM,2013) as shown in Figure 2. The hardened property measured is compressive strength. The compressive strength was measured using a 3000kN compression testing machine following ASTM C109 (ASTM,2016) procedures, as shown in Figure 3. Cubes of 50mm were used in this experiment.

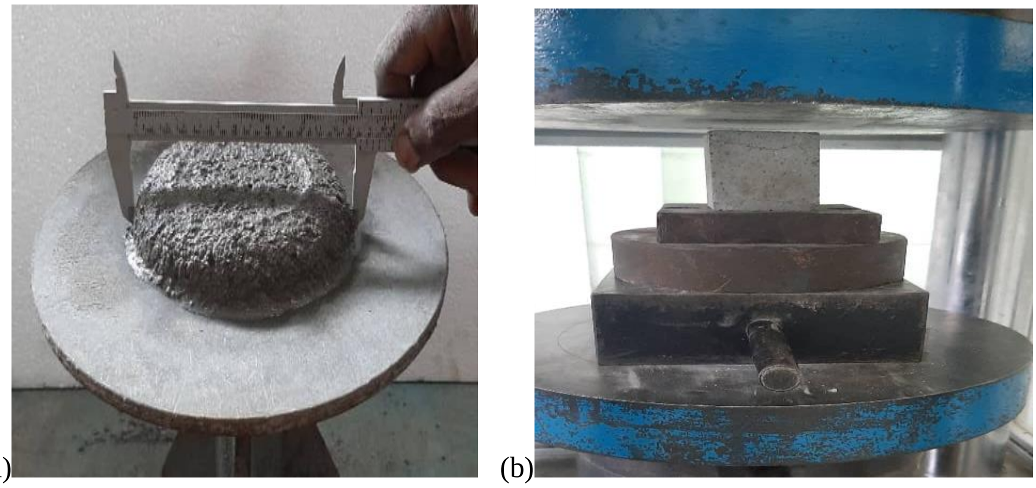
(a) (b)


Figure 2: Experimental Set-up: (a)Mortar flow (b)Compression Test

Experimental Results

Workability

Workability is the property of mortar that allows for adequate compaction, placement, and finish without segregation and/or bleeding. The flow cone test measured the flowability of control and EM mortar samples. Figure 4illustrates the mortar flow after the flow cone tests. It is observed that the workability of EM mortars was similar. EM mortars had higher workability than control mortars, as shown in Figure 4. Control mortar had a flow diameter of 150mm, while EM1 and EM2 mortars had 155mm.The increase in workability is attributed to the lubrication effect of EM in the mixes. About a 5% increase in workability was observed in EM mortars compared to the control. The increase in workability due to the presence of EM will reduce the production cost of mortar as plasticizers may be unnecessary, thereby promoting green and cost-effective mortar.

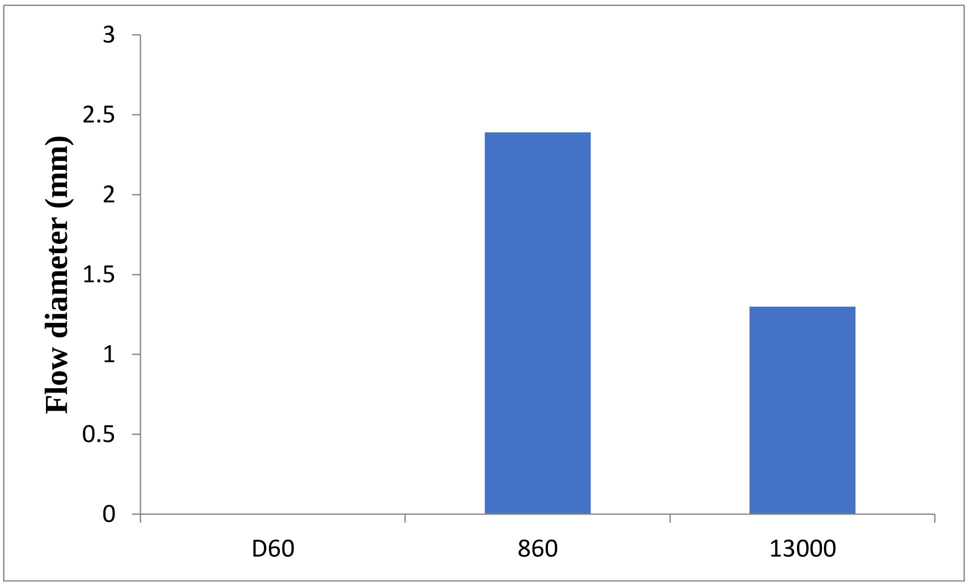


Figure 4: Flow Diameters of control and EM Mortars at 28days

Compressive Strength

Figure 5 represents the compressive strengths of EM mortars at 3, 7 and 28 days. As expected, compressive strength progressively increased as curing ages increased in all mixes. This is attributed to the progressive hydration process as curing age increases. It was observed that the EM mixes had a great gain in strength, up to 19%. At 28 days, the compressive strength of the control mortar was 45.06 N/mm^2. There was a gain of 19% and 11% for EM1 and EM2 mortars. The strength gain is attributed to calcium carbonate synthesis by EM, which plugged pore spaces within the mortar matrix. However, EM1 performed better than EM2.

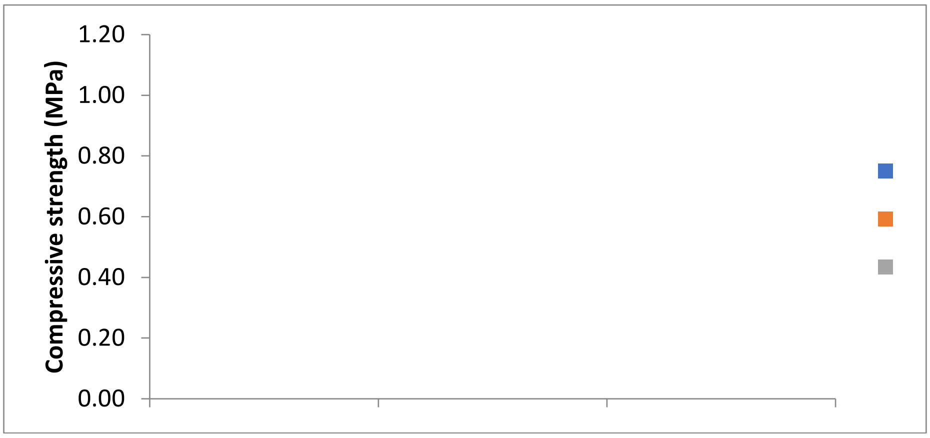


Figure 5. Compressive strength of control and EM mortars across curing days

Figure 6 depicts the compressive strength of the mortar mixes containing different concentrations of Ems. EM1MC1 and EM2MC1 represent EM1 and EM2 mortars containing 10% EM, while EM1MC2 and EM2MC2 represent mortars with 15% EM. It is observed that control samples had the lowest compressive strength (38.75N/mm^2) at 28days. EM mortars performed better in terms of compressive strength. The gain in strength could be partly attributed to the microbial synthesis of calcium carbonate. The presence of calcite within the matrix improved its compactness and, consequently, compressive strength. However, samples with an EM concentration of 15% had the highest compressive strength as compared to those containing 10%. At 28days, EM1MC1, EM2MC, EM1MC2 and EM2MC2 samples has compressive strength of 19%, 11%, 26% and 18% above control respectively. Overall, it is clearly observed that EM1MC2 hadthe highest compressive strength. This implies that EM1 propelled better modifications within the interstitial zone and pore spaces of the mortar matrix. This may also result from the capacity of microorganisms contained in EM1 to withstand the harsh environment of mortar better than EM2

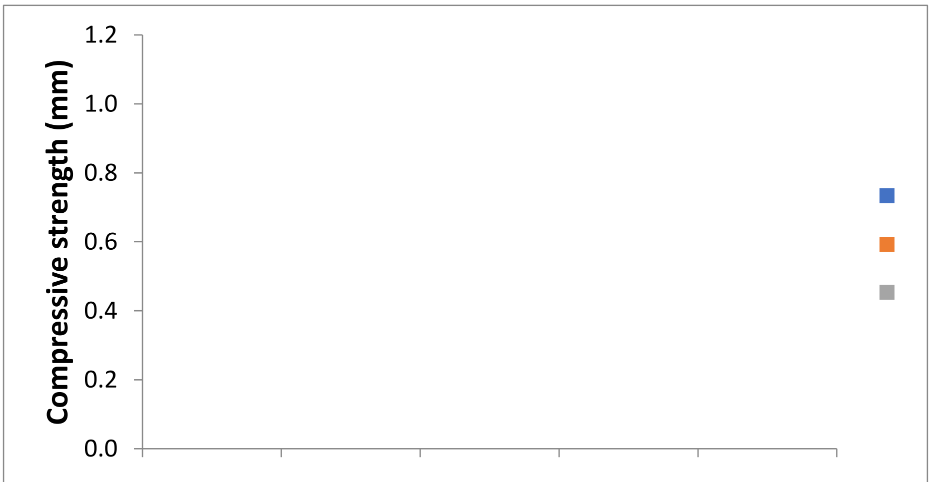


Figure 6: Compressive Strengths at Different Dilution Ratio

Conclusions

Effective Micro-organism mortars showed higher compressive strength than the control mortar at all ages. An increment of about 20% was recorded with the addition of EM. However, the best result for compressive strength was achieved by EM1 mortars. Overall, EM1MC2 showed the highest compressive strength indicating the suitability of EM to improve the properties of mortar.

References

ASTM C114, 2004. Standard Test Methods for Chemical Analysis of Hydraulic Cement 1., *i*, 1–31.

ASTM C109 , 2005. Standard Test Method for Compressive Strength Of Cement Mortars. 1–6.

ASTM C128,2004. Standard Test Method for Density , Relative Density (Specific Gravity), and Absorption. 1–6.

ASTM C1437, 2013. Standard test method for flow of hydraulic cement mortar. *ASTM Int*. doi:10.1520/C1437-15.

Basha, S., .Lingamgunta, L., Kannali, J., Gajula, S., Bandikari, R., Dasari, S., Dalavai, V., Chinthala, P., Gundala, P.B., Kutagolla, P., Balaji, V.K., (2018). Subsurface endospore forming bacteria possess bio-sealant properties, Sci. Rep., 8.1–13.

Bertron, A. Erratum to: Understanding interactions between cementitious materials and microrganisms: a key to sustainable and safe concrete structures in various contexts, Mat. and structs., 48(2015), 513. [15]

Chen, C., Habert, G., Bouzidi, Y., & Jullien, A. (2010). Environmental impact of cement production : detail of the different processes and cement plant variability evaluation. *Journal of Cleaner Production*, *18*(5), 478–485. https://doi.org/10.1016/j.jclepro.2009.12.014

Danner, T., Justness., Geiker, M., Andreas, R. (2015) Phase changes during the early hydration of Portland cement with, Cem. Concr. Res., 69, 50–60.

Giner, V., Ivorra, S., Baeza, F.J., Zornoza, E., Ferrer, B. (2011). Silica fume admixture effect on the dynamic properties of concrete, Constr. Build. Mater. 25. 3272–3277.

Guo, X.I., Shi, H.S. (2008). Thermal treatment and utilization of flue gas desulphurization gypsum as an admixture in cement and concrete, Constr. Build. Mater. 182 22. 1471–1476.

Hemavathi, S.S., Kumaran, A., Sindhu, R. (2019). An experimental investigation on properties of concrete by using silica fume and glass fibre as admixture, Mater. Today, Proc.

Hutkins,R.W., and Nannen,N.L. (1993) pH Homeostasis in lactic acid bacteria, J. Dairy Sci. 76. 2354-2365.

Irfan, M. (2011) Carbon Footprint of Ready Mix Concrete and the role of environmental classification systems, M.Sc Thesis, Chalmers University of Technology, Sweden

Kumar, M.P., Mini, K.M., and Rangarajan, M. (2018) Ultrafine GGBS and calcium nitrate as concrete admixtures for improved mechanical properties and corrosion resistance, Constr. Build. Mater. 182.249–257.

Latawiec, R., Woyciechowski, P., Kowalski, K.J. (2018). Sustainable concrete performance CO_2 -emission, Environments.

Padan, E., Bibi, E., Ito, M., Krulwich, T.A. (2005) Alkaline pH homeostasis in bacteria: new insights, Biochem. Biophys. Acta - Biomembr., 1717. 67–88.

Papadimitriou, K., Alegría, A., Bron, P.A., De Angelis, M., Gobbetti, M., Kleerebezem, M., Lemos, J.A., Linares, D.M., Ross, P., Stanton, C., Turroni, F. (2016) Stress physiology of lactic acid bacteria, Microbiol. Mol. Biol. Rev., 80. 837–890

Seifan, M., Samani, A.K., Berenjian, A. (2016) Bioconcrete: Next Generation of self-healing concrete, Appl. Microbiol. Biotechnol., 100. 2591-2602.

Mohammed, T.U., Ahmed, T., Apurbo, S.A., Mallick, T.A., Shahriar, F., Awal, M.A. (2017). Influence of chemical admixtures on fresh and hardened properties of prolonged mixed concrete, Advances in Materials Science and Engineering 2017

Wang, J, Ersan, N., Boon, N., De Belie. (2016). Application of microorganisms in concrete: a promising sustainable strategy to improve concrete durability, Appl. Microbiol. Biotechnol. 100, 2993–3007.

Wang, T. (2019). • U . S . and world cement production 2010-2018. *Statista*, 1–13.

Microstructure and Sorption Properties of Alkaline Surface Modified Coir Bio Fibre

Kure, M. A[1a], Olawuyi B. J.[1b], Ogunbode E. B.[1c], Apeh J. A.[1d]
[1] Department of Building, Federal University of Technology, P.M.B 65 Minna
[a]aliyukure7707@gmail.com; [b]babatunde@futminna.edu.ng; [c]ezekiel@futminna.edu.ng;
[d]apehjoe@futminna.edu.ng
corresponding author: aliyukure7707@gmail.com

Abstract

Natural fibres have attracted the attention of researchers and scholars due to its advantage over conventional fibres. Coir fibre is a natural bio fibre extracted from coconut plant with the advantage of low cost, low density, specific tensile properties, renew-ability, recyclability; bio-degradability and is non-abrasive to the equipment. It contains lignin, hemicelluloses, wax and cellulose. The hydrophilic nature of bio fibres poses a challenge in utilisation as reinforcement for structural applications in concrete, mortar and polymer. It has however been found in recent times to be an effective reinforcement material in cement and phenolic matrices when subjected to better surface that modifies its hydrophilic nature. This paper presents an investigation into the alkali surface treatment of coir fibre and its effect on the cleanliness of the surface from dirt and fibre sorption characteristics. The natural fibre was treated by immersion in varied NaOH concentration (0 to 20% at 2.5% step increment) of sodium hydroxide solution (NaOH) for varied period of 6 hrs. Interval up to 108 hrs. The specimens were also examined for morphology and microstructure properties using the scanning electron microscopy (SEM). The SEM micrograph revealed the specimen treated in 10% NaOH concentration at 24 hours of immersion period as having the smoothest surface and most cleaned. The examined sorption characteristics of the treated fibres further affirm that the water absorption became relatively stable for all specimen after 24 hrs and optimum within the 24 to 48 hrs treatment, while lowest absorption for the fibre treated in 10% NaOH being a value 383% at both 54 hrs and 72 hrs.

Keywords: Bio fibres, Coir fibre, surface treatment, fibre sorption, composite construction

Introduction

Shelter or housing is one of the three main needs of Man while a healthy and comfortable living environment has been adjudged as a means of mitigating spread of diseases and avoiding pandemic. Concrete though being a major material in construction and is noted to be subject to a variety of environmental conditions throughout its service life. The durability of a concrete structure is therefore defined by its ability to withstand these exposed conditions without major rehabilitation. It is believed that concrete is an inherently durable material, which can last many decades or even centuries with little maintenance. However, the relatively low tensile strength and brittle behaviour in tension necessitates the use of reinforcement (steel bars or fibres) in most structures while steel bars are still predominantly applied and the use of fibres also developed in the past decades (Muthu *et al.*, 2016).

Generally, normal concrete is known with very low tensile strength, little ductility, low resistance to cracking and limited energy absorption. It is an acceptably brittle material when exposed to impact load and normal stress, where its tensile strength is roughly one tenth of compressive strength, reinforcement with steel bars is required to withstand tensile stresses and recompense for the deficiency of ductility and strength. Improving the toughness of the concrete and decreasing the size and possibly the weaknesses would lead to better concrete performance. However, fibres incorporation in concrete is becoming necessary due to its ability to enhance concrete performance at its peak. The inclusion of fibres into concrete mixture could be of solution towards enhancing its tensile strength, flexural strength and ductility, which are improved sort of reinforcement that could enhance concrete ingredients in the bonding with cement composite (Ogunbode *et al.*, 2015).

The main barrier against the selection of fibrous materials in construction work is its moisture sorption ability at all levels. The moisture absorption by natural fibres leads to swelling of the material, dimensional change, reduction in rigidity of cell wall, poor strength and stiffness. In moisture sorption process; hemicelluloses, non-crystalline cellulose, lignin, and surface morphology of fibre plays an important role. Hence, to make good choice of lignocellulosic materials, it is highly required to understand, estimate, and overcome the water intake behaviour of the natural fibres. However, for proper analysis and comparison of the water absorption of untreated and alkali treated fibres, it is imperative to prepare fibre bundles in the same pattern (Mwaikambo *et al.*, 2006).

Natural fibre (coir) has become of great interest to researchers because of its superior properties to other fibres. Natural fibres are prone to water absorption due to their chemical composition and the richness in cellulose and hydrophilic in nature. Water absorption of natural fibre is more likely to increase with the increase in cellulose content of the fibre due to the increase in the number of free hydroxyl groups existing in the fibre. Also, moisture absorption capacity increase with an increase in fibre content and due to moisture absorption, micro cracks get initiated in the composite (Ogunbode *et al*., 2016).

Moisture absorption capacity increase with time and get saturated after reaching the saturation point after which it becomes constant. Considering the advancement in technology, chemical treatment can be used to reduce the water absorption capacity. In this paper, Coir fibre as one of the best natural fibres was studied. It is noted to be of advantages over others such as being; cheap, renewable, of low-density, non-abrasive. The hydrophilic nature of coir fibre makes the composites to absorb water which in turn reduces the interfacial bonding between fibres and resin. In order to reduce the amount of water absorption, fibres are pre-treated (Hosne *et al*., 2021).

Alkali treatment of coir fibres could improve the interfacial bonding properties and the wet ability of the fibres by leading to the enhancement in mechanical properties of concrete. Natural fibres are known with different behaviour after absorption of moisture. Previous studies have shown that under wet conditions bio composites achieve better wear performance as compared to dry conditions. Damping capacity of material shows its amount of elasticity. Moisture affects the fibre structure differently as it has both positive and negative impacts on the fibre performance. These effects constitute the following: crack propagation, sliding surface reaction and body layer of accumulated wear debris (Awasthi *et al*., 2021).

The main barrier against the selection of fibrous materials in construction work is its moisture sorption ability at all levels. The moisture absorption by natural fibres leads to swelling of the material, dimensional change, reduction in rigidity of cell wall, poor strength and stiffness. In moisture sorption process; hemicelluloses, non-crystalline cellulose, lignin, and surface morphology of fibre plays an important role. Hence, to make good choice of lignocellulosic materials, it is highly required to understand, estimate, and overcome the water intake behaviour of the natural fibres. However, for proper analysis and comparison of the water absorption of untreated and alkali treated fibres, it is imperative to prepare fibre bundles in the same pattern (Mwaikambo *et al*., 2006).

Natural fibre (coir) has become of great interest to researchers because of its superior properties to other fibres. Natural fibres are susceptible to water absorption due to their chemical composition and the richness in cellulose and hydrophilic in nature. Water absorption of natural fibre is more likely to increase with the increase in cellulose content of the fibre due to the increase in the number of free hydroxyl groups existing in the fibre. Also, moisture absorption capacity increase with an increase in fibre content and due to moisture absorption, micro cracks get initiated in the composite. However, Moisture absorption capacity increase with time and get saturated after reaching the saturation point after which it becomes constant. Considering the advancement in technology, chemical treatment can be used to reduce the water absorption capacity (Hosne *et al*., 2021).

The hydrophilic nature of coir fibre makes the composites to absorb water which in turn reduces the interfacial bonding between fibres and resin. In order to reduce the amount of water absorption, fibres can be pre-treated (Hosne *et al*., 2021).

Materials and Methods

Portland cement type II (PC CEM II 42.5) in compliance with the standard of ASTM C 150-07was used and the coir fibre used was collected from local sources in Minna and it environ. The fibre was treated with varied percentages of sodium hydroxide concentration and washed thoroughly in clean distilled water to remove all remnant of alkali on the fibre surface. The fibres were prepared for water absorption test by the alkali (NaOH) treatment process, which included scouring of the fibres, rinsing, and neutralisation finally exposed to air for drying before the sorption test was carried out.

(a) (b)

Figure 4: Coir fibre (a) un-treated, (b) treated

The treated fibres were then uncurled by hand and combed with a steel comb before putting it in required arrangement. The average diameter of the coir fibre used in this experiment is 0.25mm. The fibre was treated by soaking it in various concentrations (0 to 20 at 2.5% incremental steps) of NaOH solutions. They were then drained and weighed to determine the sorption property. The percentage sorption (S %) was then calculated using equation 1.

$$S = \frac{w - w_o}{w_o} \times 100 \qquad (1)$$

Where: S= Absorption; w = weight after immersion; w_0 = weight before immersion (initial weight).

The fibres (treated and untreated) were then air-dried and sent to Rolab Research and Diagnostic Laboratory in Ibadan, Oyo State, Nigeria for scanning electron microscopy -SEM (Figure 2) to study the morphology and microstructure as effected by the treatment using the SEM machine (JOEL-JSM 7600F) as shown in Fig. 2.

Figure 5: SEM Machine (JOEL-JSM 7600F)

Results and Analysis

Table 1 presents the results of sorption of the Coir fibre subjected to varied concentration of NaOH (0 to 20% at 2.5% steps interval) at different immersion periods (0 to 108 hrs at 6 hrs step intervals).

Table 64: Sorption Properties of Coir Fibres Treated in NaOH Solution (in %)

Hrs	NaOH concentration (%)

	0	2.5	5	7.5	10	12.5	15	17.5	20
6	36 (600)*	24 (400)	21 (350)	22 (367)	22 (367)	24 (400)	26 (433)	22 (367)	25 (417)
12	36 (600)	26 (433)	21 (350)	24 (400)	27 (450)	26 (433)	24 (400)	22 (367)	22 (367)
18	38 (633)	24 (400)	19 (317)	24 (400)	25 (417)	25 (417)	22 (367)	26 (433)	22 (367)
24	32 (533)	25 (417)	24 (400)	23 (383)	28 (467)	27 (450)	27 (450)	26 (433)	24 (400)
30	32 (533)	26 (433)	24 (400)	24 (400)	29 (483)	25 (417)	24 (400)	25 (417)	24 (400)
36	33 (550)	27 (450)	24 (400)	26 (433)	29 (483)	26 (433)	26 (433)	26 (433)	23 (383)
42	36 (600)	28 (467)	23 (383)	24 (400)	29 (483)	23 (383)	25 (417)	26 (433)	23 (383)
48	38 (633)	28 (467)	24 (400)	25 (417)	29 (483)	24 (400)	25 (417)	26 (433)	22 (367)
54	41 (683)	29 (483)	25 (417)	28 (467)	23 (383)	24 (400)	26 (433)	27 (450)	23 (383)
60	44 (733)	28 (467)	21 (350)	24 (400)	28 (467)	23 (383)	22 (367)	24 (400)	23 (383)
66	44 (733)	28 (467)	22 (367)	24 (400)	28 (467)	23 (383)	24 (400)	25 (417)	22 (367)
72	46 (767)	28 (467)	24 (400)	28 (467)	23 (383)	22 (367)	24 (400)	25 (417)	22 (367)
78	46 (767)	28 (467)	21 (350)	23 (383)	28 (467)	23 (383)	22 (367)	24 (400)	22 (367)
84	49 (817)	28 (467)	21 (350)	22 (367)	28 (467)	21 (350)	23 (383)	24 (400)	22 (367)
90	49 (817)	28 (467)	24 (400)	28 (467)	22 (367)	22 (367)	24 (400)	24 (400)	22 (367)
96	52 (867)	27 (450)	20 (333)	23 (383)	27 (450)	23 (383)	21 (350)	24 (400)	22 (367)
102	52 (867)	28 (467)	21 (350)	22 (367)	28 467)	21 350)	21 (350)	23 (383)	21 (350)
108	52 (867)	28 (467)	24 (400)	26 (433)	22 (367)	21 (350)	24 (400)	24 (400)	22 (367)

***Values in parenthesis () represents the percentage absorption relative to the initial fibre weight.**

The Table reveals that the NaOH treatment greatly reduced the sorption tendencies of the fibres. While the untreated fibre has absorption value was as high as 600% of the fibre weight, the absorption of the treated fibres generally increased (350 to 400%) as the NaOH solution concentration increased up to 10% except for the 2.5% NaOH solution which seems higher. The sorption value however showed a decline in sorption value thereafter. Similarly, the sorption of the treated fibres for all concentration of NaOH solution generally increased with increase in period of immersion up to 24 hrs, beyond which the absorption value became relatively constant up to the 48 hrs immersion period (Table 1 and Fig.3). It can thereby be inferred that the 10% NaOH solution treatment of the fibres for 24 hrs period can be accepted as the possible optimum treatment required for effectiveness of the fibre. A look at Fig. 3 (yellow values) revealed the steady/stable sorption values observed within the 24 to 48 hrs immersion period for the 10% NaOH solution treatment of the Coir fibre.

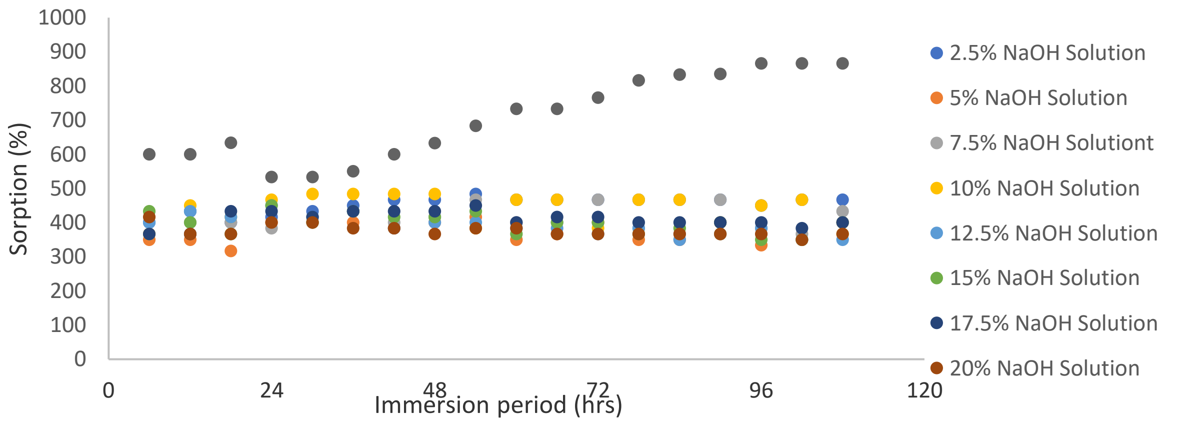


Figure 6: Sorption Properties of Coir Fibre Treated in NaOH Solution

Figures 4 and 5(a – h) shows the SEM micrographs of the Coir fibres subjected to varied NaOH solution treatment for 24 hrs immersion period. The natural coir fibres as seen in Figures 1a and 4 are clustered together (i.e., individual strings of the fibre could not be separated) while the treated fibres in Figure 1b had the individual strings clearly seen and identified.

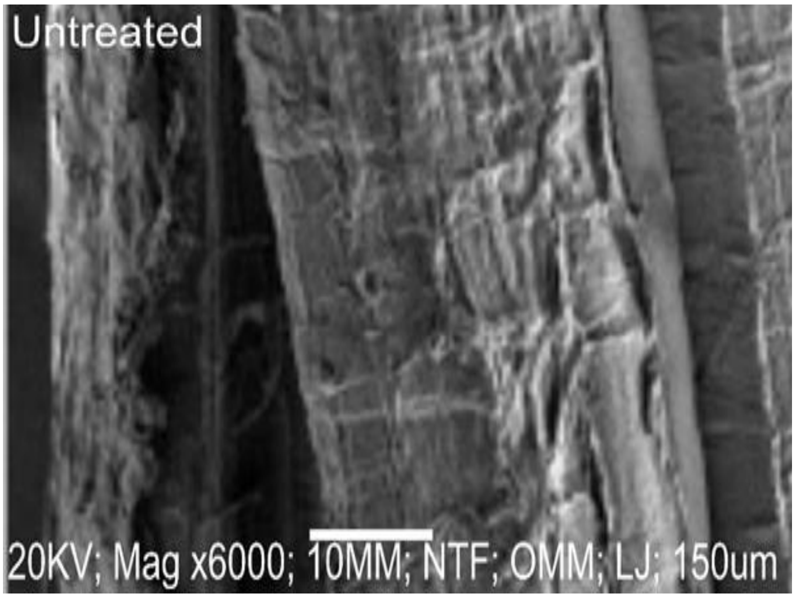


Figure 7: SEM Micrograph of Untreated Coir Fibre (i.e., in 0% NaOH)

The SEM micrograph of the treated fibres is presented in Figure 5 (a - h).

A keen view at the micrograph shows cracks in the fibres for treatments in concentrations of 12.5% NaOH and above, while treatments in concentrations between 0 and 7.5% shows some rough and unclear surfaces. The treatment in 10% NaOH solution was observed to be the clearest with no indication of cracks on the fibre. This is in agreement with the results gotten for the sorption properties of the fibre which indicated that treatment in 10% NaOH solution for 24 Hrs as the ultimate for the Coir fibre sample.

Conclusion

In this work, sorption and microstructure of Coir fibres subject to varied (0 to 20% at 2.5% steps) NaOH solution has been studied. The fibre immersed to 10% NaOH solution for 24 hrs was found to be the optimum treatment and observed to be of clear surface and not exhibiting cracks. It is thereby recommended for adoption as appropriate for treatment of Coir fibre for use in concrete or mortar works.

Reference

ASTM C150-07: Standard Specification for Portland cement. ASTM Standards, 2007.

Awasthi A. B, Partha P., Vijay C. (2021) Effect of moisture absorption on the properties of natural fibre polymer composites: A review

Hosne A. B, Tanima R. T., Shahid M. d (2021) Analysis of Water Absorption of different Natural Fibers. Department of Yarn Engineering, Bangladesh University of Textiles, Dhaka, Bangladesh *Journal of Textile Science and Technology, 7, 152-160*https://www.scirp.org/journal/jtst*ISSN Online: 2379-1551 ISSN Print: 2379-1543*

Muthu K. T, Sirajudeen. K (2016), "Experimental Investigation on High Performance Concrete Using Alternate Materials", *International Journal of Research in Engineering and Technology, Volume: 6 Issue: 14, 175-181.*

Mwaikambo, L. Y., and Ansell, M. P. (2006). Mechanical properties of alkali treated plant fibres and their potential as reinforcement materials. I. Hemp fibres. *Journal of Materials Science 41 (8):2483–96.*

Ogunbode E. B., Jamaludin M. Y., Ishak M. Y., Meisam R., Masoud R., Norazura M.A. (2016). Preliminary Investigation of Kenaf Bio Fibrous Concrete Composites., 2nd Int. *Conference on Science, Engineering Social Science. UTM, Johor Bahru, Malaysia, 248–249.*

Ogunbode, E. B., Jamaludin, M. Y., Ishak, M. Y., Razzavi, M. (2015). Potential of Kenaf fibre in bio-composite production: A review, Journal Teknologi, 77(12), 3-30

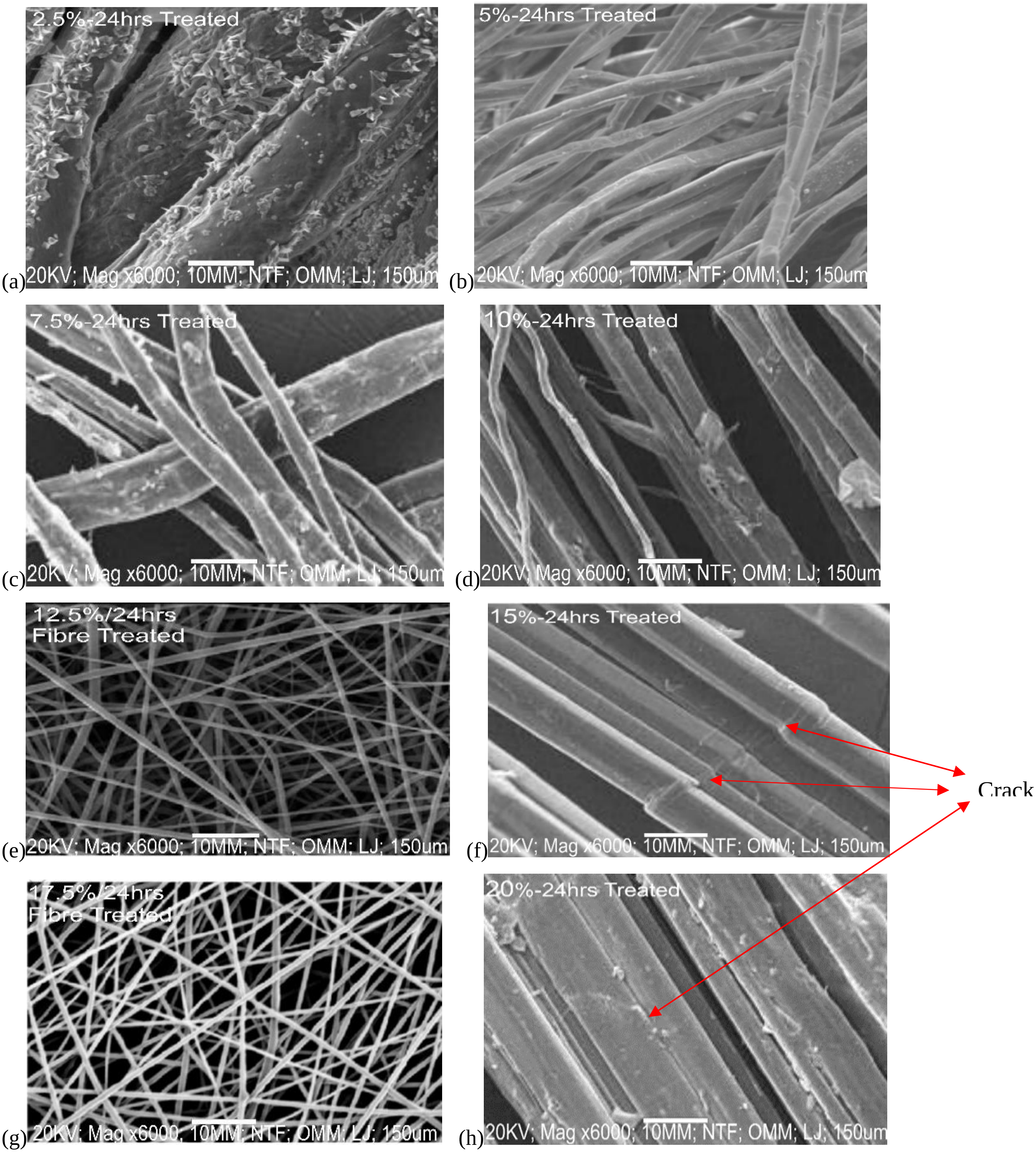


Figure 8: SEM Micrograph of Coir Fibresin (a) 2.5%; (b). 5%; (c). 7.5%; (d). 10%; (e).12.5%; (f). 15%; (g). 17.5% and (h). 20% NaOH Solutions

Nanotechnology Application in the Development of Fonio Husk Ash and Calcium Carbide Waste Based-Binder Mortar

Abeku, D.M. [1a], Apeh, J.A. [1c], Olawuyi, B.J. [1b], & Hassan I.O.[2a]
[1]Department of Building, Federal University of Technology, Minna, Nigeria.
2Department of Building, Federal University, Lafia, Lafia, Nigeria.
abekuderi@gmail.com, babatunde@futminna.edu.ng, apehjoe@futminna.edu.ng, Ibrahim.hassan270@gmail.com
Corresponding email: abekuderi@gmail.com

Abstract

One of the measures taking during COVID-19 Pandemic was to avoid crowded places like markets, places of worships and others. The living environment of many of the low-income group of the Society is generally noted for been crowdy, un-hygienic and hence are avenue for ease spread of diseases during epidemic/pandemic. This therefore necessitate further research works towards sustainable low-cost houses using eco-friendly binders. This is coupled with the challenge of high carbon – dioxide (CO_2) emission, energy consumption and environmental degradation associated with Portland cement (PC) production. Recent efforts at the utilization of Agricultural wastes (rice husk ash (RHA); millet husk ash (MHA); sorghum husk ash (SHA), etc.) in combination with calcium carbide waste (CCW) for green concrete development gave reports of slow hydration and strength development. Hence the need for developing methods of improving the performance of the eco-friendly binders for which this study is one. This research examines the combination of FHA and CCW (agro - industrial wastes) with the incorporation of nanotechnology for improved hydration and strength enhancement. The study adopted a qualitative approach where Fonio husk obtained from Jaba Local Government Area of Kaduna State was incinerated using the locally fabricated incinerator in the Concrete Laboratory of the Department of Building, Federal University of Technology, Minna. Calcium Carbide waste obtained from Auto-mechanic village in Keteren Gwari area of Minna was oven-dried and calcined too and then pulverised. The FHA and CCW samples were analysed using an X-ray florescent machine to ascertain their chemical composition and further subjected to cement - based tests (i.e., setting time, consistency, soundness and strength tests). Trial combinations of FHA/CCW at 55/45, 50/50 and 45/55 was used as alternative binder in mortar mixes with the cast mortar cubes cured and crushed for compressive strength at 3, 7, 14 and 28 days. Data presented using tables were analysed for an informed conclusion on the performance of FHA/CCW binder – based mortar.

Key words: *Nano – silica particles (NSP), Fonio Husk Ash (FHA), Calcium Carbide Waste (CCW), eco – friendly binders, green concrete.*

1 Introduction

The COVID-19 experience world-over necessitates the need to discourage living in crowdy and un-healthy environments with the poor and low-income groups of the society noted to live generally in very crowdy and clustered areas with little or no provision at all for toilets and proper hygiene due to the ever-increasing high cost of construction. In a report by the Nigeria Centre for Disease Control (NCDC on the recent outbreak of Diphtheria, people who live in a crowded environment, in areas with poor sanitation and healthcare workers are the most susceptible to be infected (Premium Times, 25th Jan. 2023). This implies research sustainable low-cost building to house the rural mass using eco-friendly binders has to be a continuous thing.

Portland Cement (PC) known to be the major binding material used in the construction industry is poised with lots of challenges such as: the production of involves a lot of energy consumption; has been advocated to contribute above 5% of the total global anthropogenic carbon dioxide (CO_2) emission (Natapong *et al*., 2010); the challenge of climate change due to global warming (greenhouse gas, GHG)) which results from (CO_2) emission into the atmosphere is also a major problem. The impact of these emissions on the environment has caused many to focus on CO_2 emissions as the most critical environmental impact indicator (Natapong *et al*., 2010). Cement manufacture contributes GHG both directly through the production of CO_2 when calcium carbonate ($CaCO_3$) is thermally decomposed, producing lime (CaO) and CO_2; and also, through the use of energy, particularly from the combustion of fossil fuels (Environmental Impact Assessment EIA, 2011).

Gupta (2014) posits that there has been a lot of efforts made towards the reduction of the CO_2 emission from concrete primarily through the use of lower amounts of cement and higher amount of supplementary cementitious material (SCM). This will translate into a reduction in the GHG emission thereby giving rise to a safer environment. Gupta (2014) thereby concludes that green materials are mostly recycled, reusable or by-products and wastes which are environmentally friendly. In agreement with the above position, Saurabh (2016) asserts that green concrete is eco-friendly and saves the environment by using waste products generated by industries. Saurabh (2016) added that the use of green concrete helps in saving energy, emissions, waste water and it also leads to a cheaper concrete material. Jagadish *et al*., (2015) also asserts that a large number of industries produce waste materials which need to be either disposed-off or utilized for some other purposes. In most cases, disposal of these wastes usually poses major problems where in some cases large chunks of land are usually rendered useless or unusable due to disposal of such wastes. Nigeria being an agrarian society has plenty of post-harvest agro-wastes, while some industrial by-products abound, constituting a nuisance to the environment. These materials if well processed could serve as the requisite alternative green binder.

Fonio also called "*digitarial exilis*" or "*digitarial eburua*" is known as "*Acha*" in Hausa language. The husk obtained from de-husking the grain is one of the agro-wastes that are generated annually. This study aims at using the ash obtained from incinerating the Fonio husk in combination with Calcium Carbide Waste (CCW) - a by-product of acetylene gas welding (an industrial waste) for utilization as a substitute for PC in mortar. These two waste materials constitute environmental nuisance and hazards, because when they are not disposed-off properly, the FHA emits foul odour after rainfalls or the Fonio husks if undisposed can also be blown off by wind as dust, while the CCW can leach harmful chemicals into the ground when washed by rain thereby making underground water to become unwholesome. The need for an investigation into the utilization of FHA and CCW as an alternative binder in mortar/concrete will go a long way towards establishing green and eco – friendly construction.

Vichan & Rachan (2013); Horpibulsuk *et al*., (2011) defined CCW or carbide lime as a by-product of acetylene manufacturing, which dissolves in water to produce $Ca(OH)_2$. CCW and hydrated lime are similar in their chemical and mineralogical compositions with the exception of the presence of carbon in CCW. Makaratat *et al*., (2010) studied calcium carbide waste – fly ash (CCW-FA) concrete, for a weight ratio of 30-70 (CCW-FA) used as a binder to cast concrete. CCW was reported to have specific gravity value of 2.32 (Horpibulsuk *et al*., 2011). Yunusa (2015) asserted that concrete cubes cast using 0 to 50% replacements at 10% step increments replacement of cement with CCW possess the properties (such as setting time, soundness and workability) of PC cubes with reduction in compressive strength when exceeding 10% replacement owing to increase in water absorption of the mix. Gupta & Wayal (2015) used CCW ground in a mill to increase its fineness and was mixed with fly ash (FA) at a ratio of 30:70 (CCW: FA) as a binder without PC. The setting times (initial and final) of CCW: FA concretes were much longer than the normal concrete with compressive strength values between 19.0 and 24.7 N/mm^2 at 28 and 90 days respectively. The lower the W/B ratio, the higher the compressive strength of CCW: FA concrete. The hardened concrete was reported to be of same properties as that of the PC-based concrete (Makaratat *et al*., 2010). Jaturakkul & Roongreeung (2003) worked on cementing material from CCW and RHA and reported that a pozzolanic reaction occurred when CCW is mixed with RHA for mortar and achieved a highest compressive strength of $15.6N/mm^2$ at 28 days of age.

In the past research effort was centred on partial replacement of PC with SCM. The work of Ndububa *et al.,* (2016) on FHA showed that it could be used to replace PC up to 10% without adverse effect on compressive strength. The study further showed that the tricalcium silicate (C_3S) content in the ash was not too significant. It was established in literature Neville (2013); Mehta and Monteiro (2014) that C_3S content in PC is responsible for its fast reaction. Studies also revealed that the di-calcium silicate (C_2S) content of the FHA was high which accounts for the slow setting and hydration of concrete produced as evidenced both in the work of Ndububa *et al.*, (2016) and Matawal (2012). Recently, study on total replacement of PC with agro-industrial based waste materials (RHA/CCW and MHA/CCW) has been reported by Olawuyi *et al*., (2017) with promising results obtained, but revealed slow hydration and low strength characteristics.

Yu Chen, *et al*., (2016) worked on the influence of Nano-silica particles (NSP) on the consistency, setting time, early-age strength and shrinkage of composite cement pastes and concluded that there was significant reduction of setting times and that the effect of the NSP was remarkable as there was also improved early–age strength development when NSP was added to the mix. The influence of NSP was also seen on early age shrinkage which was due to smaller sizes of the NSP because of higher surface area leading to a higher reactivity (Yu Chen *et al*., 2016). Narender & Meena (2017) in their work reported that Nanotechnology is an interesting but emerging field of study which is under constant evolution offering a very wide scope of research activity. It was stated that if the particle size ranges between 1nm to 100nm, they are generally called Nano-particles or materials. As fineness increases, the surface area increases, which also increases the 'reactivity' of the material. Narender & Meena (2017) hold the view that the application of Nano-cement in concrete can lead to significant improvements in the strength and life of the concrete. The use of finer particles which translates to higher surface area has advantages in terms of filling the cement matrix and increasing the density of the concrete thereby resulting in higher strength and faster chemical reaction which is also called hydration. Nano-cement particles can accelerate cement hydration due to their high re-activity. They can fill pores more effectively to enhance the overall strength and durability of concrete (Narender & Meena, 2017).

Narender and Meena (2017) concluded that:

i. The improvement in mechanical properties due to the incorporation of NSP was made possible because of the pore filling effect of the NSP and also due to pozzolanic reactions.

ii. The Nano-size materials reduced the pore size making the concrete denser and accounts for increase in durability.

iii. The dense parking also helps in restricting the entry of unwanted substances such as air, water and other chemicals into the concrete thereby increasing the durability of the concrete.

iv. The reason for the increase in concrete strength with increase in NSP content is that it acts as activator to promote the hydration and also to improve the microstructure of cement paste if NSP were uniformly dispersed. The strength is enhanced with NSP addition, especially at early stages, and the pozzolanic activity of NSP was greater than other materials.

v. It was observed that NSP blended concretes have higher strength as compared to non-blended-concretes, as the strength was found to be higher at all ages for NSP-blended concretes.

Most of the research works discussed above are limited to cement pastes with only a few researchers having worked extensively on mechanical properties and permeability of the concrete incorporating NSP. It is in view of the foregoing that this study aims at researching into the utilization of FHA/CCW binder incorporating NSP to cater for the already established slow hydration and low strength characteristics of the agro – industrial wastes as reported by Ndububa *et al.*, (2016); Matawal (2012) and Olawuyi *et al.*, (2017).

2. Materials and Method

This study adopted the inductive method of research design where materials were sourced and taken to the Concrete Laboratory of the Building Department of the Federal University of Technology, Minna for processing. The materials used in the study are discussed in the following subsections.

2.1 Portland Cement (PC)

The PC (CEM I 42.5 N) used for this study is the Dangote (3X) brand of cement. The reason for the use of this brand is that it is readily available in the research location and its strength has been attested to by many users. Precaution was taken to ensure that the cement was of recent supply and free of adulteration. The cement as stated in the package conforms to NIS 444-1: 2003.

2.2 Fonio Husk Ash (FHA)

The Fonio husk was obtained from Fonio milling shops in Kwoi, Jaba Local Government of Kaduna State and taken to the Concrete Laboratory of the Building Department of Federal University of Technology, Minna and calcined using the locally fabricated incinerator available in the Laboratory. The resulting ash was then taken to the Civil Engineering Department of the Federal Polytechnic Bida for pulverising using the Los Angele's Abrasion Testing Machine.

The ash was sieved using the 75 and 45µm sieves before three (3) kilograms of the ash passing through the 45µm taken to the Centre for Genetic Engineering of the Federal University of Technology, Minna for Nano-silica particles (NSP) production. Chemical analysis of the FHA and NSP was conducted at the Chemical Engineering Department of Kaduna Polytechnic.

2.3 Calcium Carbide Waste (CCW)

The CCW was obtained from auto – mechanic workshops at Keteren Gwari area of Minna and taken to the Building Department where it was sun-dried, subjected to further drying in the incinerator and also pulverized with the Los Angeles Abrasion machine before sieving with the 75µm sieve. A sample of the resulting CCW powder was also sent to the Chemical Engineering Department of Kaduna Polytechnic for chemical analysis.

2.4 Nano-Silica Particles (NSP)

Nano-silica particles were produced using the pulverized FHA at the Centre for Genetic Engineering, Federal University of Technology, Minna using the particles that passed through the 45µm sieve. The NSP were produced and incorporated into the mortar mix at percentages ranging from 0 to 5.0% at staggering steps.

2.5 Fine Aggregate

The sharp sand used for this research work is the natural river sharp sand obtained from the local sand suppliers in Minna, Niger State. The particles retained within 1:18 mm (Sieve No. 16) to 75µm (Sieve No. 200) in accordance with BS 812-103.1: 2000 served as the simulated reference sand, an alternative to the standard CEN reference sand.

2.6 Water

The water used for the production and curing of mortar samples of this research work was the clean potable water available at the Building Laboratory of the Federal University of Technology Minna, Niger State.

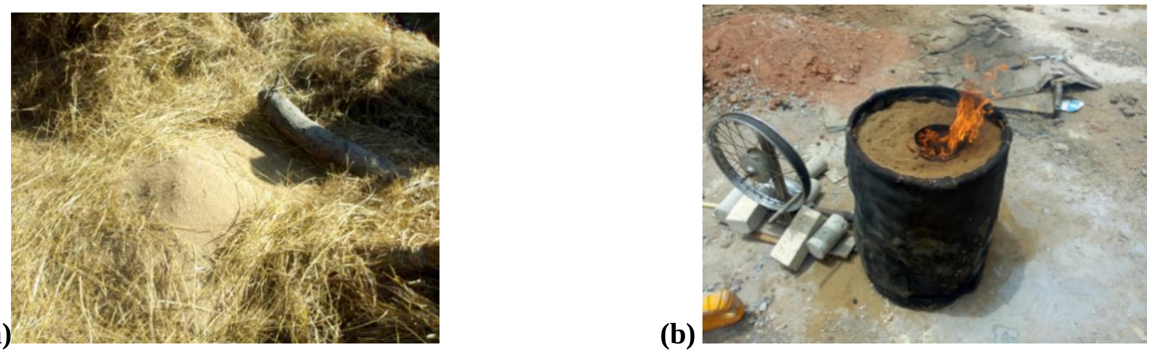
2.7 Mortar Mix Details

Mortar was prepared using 50 mm cube size in accordance with BS EN 196-1: 2016. Three combination proportions (55/45, 50/50 and 45/55) of FHA/CCW were produced as the alternative binders, while the PC based-mortar mix denoted as CEM I served as the control for the study in determining the most suitable appropriate combination proportion. The NSP content was made to vary as earlier explained at 1% steps from 0.5% to 5.0% (Table 1). Thirty (30) cubes were cast (Figure 2a) from each mix and cured for varied curing ages (3, 7, 14, 21 and 28 days). Batching and mixing of mortar samples was carried out using 1:3 cement/sand (c/s) and 0.5 water/cement (w/c) ratio as specified by BS EN 196 - 1:2016 for CEM II as control. The alternative binders comprised of varied proportion combinations of FHA/CCW, while the w/c ratio (0.65) used was noted to be slightly higher than that of the CEM II. The cast samples were kept in the mould and covered with jute bags and cured by water sprinkling for 24 hours before de-moulding (Figure 2b) and further cured in water by immersion for crushing at the various ages.

Table 1: Mix Proportions for Mortar Samples

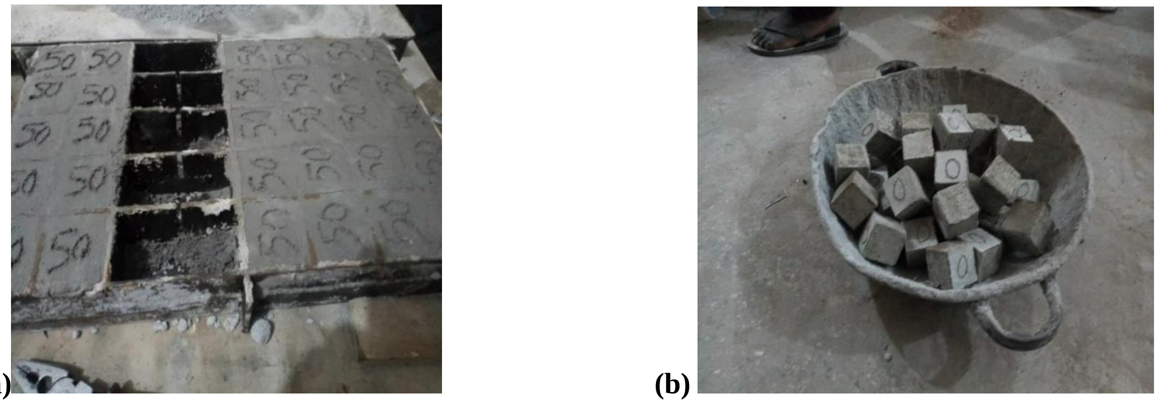
S/No	Specimen	CEM	FHA	CCW	SAND	NSP($\%_{bwob}$)	Water
1	CEM II	1775	0	0	5325	0 (=0g)	888
2	55/45a	0	975	800	5325	0 (=0g)	888
3	55/45b	0	975	800	5325	1.5 (=26.6g)	888
4	55/45c	0	975	800	5325	2.5 (=44.4g)	888
5	55/45d	0	975	800	5325	4.5 (=79.9g)	888
6	55/45e	0	975	800	5325	5.0 (=88.8 g)	888
7	50/50a	0	888	888	5325	0 (=0g)	888
8	50/50b	0	888	888	5325	1.5 (=26.6g)	888
9	50/50c	0	888	888	5325	3.0 (=53.3g)	888
10	50/50d	0	888	888	5325	4.5 (=79.9g)	888
11	50/50e	0	888	888	5325	5.0 (=88.8)	888
12	45/55a	0	800	975	5325	0 (=0g)	888
13	45/55b	0	800	975	5325	0.5 (=8.9g)	888
14	45/55c	0	800	975	5325	1.5 (=26.6g)	888
15	45/55d	0	800	975	5325	2.5 (=44.4g)	888
16	45/55e	0	800	975	5325	3.5 (=62.1g)	888
17	45/55f	0	800	975	5325	4.5 (=79.9g)	888
18	45/55g	0	800	975	5325	5.0 (=88.8g)	888

Photo Gallery



(a) **(b)**

Figure 9: (a) Harvesting of Fonio and (b) Incineration of Ash Started



(a) **(b)**

Figure 10: FHA/CCW Mortar cubes: (a) cast cubes (b) De-moulded mortar cubes

3. Results and Discussion

Table 2 presents the result of the X-ray florescent (XRF) for FHA, CCW as Compared with PC composition. From the result, it can be seen that the FHA has SiO_2 (86%) as its major oxide and total useful oxide (SiO_2 + Al_2O_3+ CaO+ Fe_2O_3) of 89% which is above the minimum content specified in ASTM C618-19 (35% for SiO_2 and 70% for total useful oxides). The CCW on the other hand has CaO

(83%) as its major oxide and this was found to be greater than the expected CaO content (67%) in typical PC. The proportion of the composition matters a lot for an assessment of the pozzolanic tendencies of the materials. This result shows that the silica is very high in the FHA. The major composition of FHA (86% SiO_2) and CCW (83% CaO), if found reactive should result in Calcium Silicate Hydrate (C-S-H).

Table 2: Oxide Composition of FHA and CCW as Compared with PC

Oxide	SiO_2	CaO	Al_2O_3	Fe_2O_3	MgO	ZnO	CuO	MnO	Cr_2O_3	TiO_2	PO	P	C	Na	SO
FHA	85.64	8.13	0	3.58	2.01	0.12	0.02	0.23	0.01	0.26	0	0	0	0	0
CCW	2.3	82.6	2.19	0.71	0.47	0	0	0	0	0	0.3	0.1	8.3	0	0
PC	17-25	60-67	3.0-8.0	0.5-0.6	0.1- 4	0	0	0	0	0	0	0	0	0.3	2.-3.5

*PC's oxide composition as provided in literature (Neville, 2012; Mehta & Monteiro, 2014).

Table 3 presents setting times result (Initial and Final). The mortar samples without the NSP had higher initial and final setting times, but after the NSP was added to the mix, the rate hydration improved tremendously where the 55/45 FHA/CCW binder without NSP gave an initial setting time of 138 minutes and a final setting time of 225 minutes (i.e. 135 minutes longer setting). This implies 150% delay when compared to CEM II based mortar samples. The 50/50 FHA/CCW binder produced an initial setting time of 140 minutes and a final setting time of 240 minutes which is 150 minutes delayed setting (167%) to CEM II, while the 45/55 FHA/CCW binder without NSP produced an initial set time of 125 minutes and a finally set at 205 minutes which is 115 minutes (128%) beyond that of the CEM II.

Results also show that after the NSP addition the hydration of the materials improved tremendously. The 55/45 FHA/CCW binder + NSP gave an average initial setting time of 118 minutes a final setting time of 210 minutes which is 120 minutes delay (133%) compared to CEM II. The 50/50 FHA/CCW binder + NSP gave an average of 105 initial setting time and a final setting time of 185 minutes which is 95 minutes delay (106%) compared to CEM II. Finally, the 45/55 FHA/CCW binder + NSP produced an initial set time of 94 minutes and a final setting time of 144 minutes which is 54 minutes delay (60%) beyond CEM II.

Table 3: Result of Setting Times of Cement and Alternative Binders

S/N	Specimen	NSP ($\%b_{wob}$)	Initial Setting Time (Mins)	Final Setting Time (Mins)	Difference with PC (Mins)	Percentage Difference (%)
1	CEM II	0	35	90	0	0
2	55/45a	0	138	225	135	150
3	55/45b	1.5	110	215	125	139
4	55/45c	2.5	115	210	120	133
5	55/45d	4.5	125	205	115	128
6	55/45e	5.0	120	210	120	133
7	50/50a	0	140	240	150	167
8	50/50b	1.5	115	190	100	111
9	50/50c	3.0	100	170	80	89
10	50/50d	4.5	95	185	95	106
11	50/50e	5.0	110	195	105	117
12	45/55a	0	125	205	115	128
13	45/55b	0.5	100	160	70	78
14	45/55c	1.5	95	145	55	61
15	45/55d	2.5	90	135	45	50
16	45/55e	3.5	100	140	50	56
17	45/55f	4.5	85	130	40	44
18	45/55g	5.0	95	155	65	72

Table 4: Compressive strength results of PC and the FHA/CCW Combinations without + NSP (N/mm^2)

S/N	Specimen	NSP (%)	3 Days	7 Days	14 Days	21 Days	28 Days

1	**CEM II -Control**	**0**	**14.11**	**18.24**	**23.31**	**27.03**	**27.58**
2	**55/45a –Control**	**0**	**1.22**	**1.37**	**1.43**	**1.51**	**1.71**
3	55/45b	1.5	1.59	1.75	1.65	2.07	2.05
4	55/45c	2.5	1.66	1.70	1.54	2.03	1.62
5	55/45d	4.5	1.65	1.77	1.67	2.48	2.48
6	55/45e	5.0	1.87	1.81	2.50	2.68	2.63
7	**50/50a -Control**	**0**	**0.87**	**0.89**	**1.04**	**1.10**	**1.16**
8	50/50b	1.5	1.83	1.91	1.78	1.95	1.77
9	50/50c	3.0	1.83	2.20	1.95	4.65	1.64
10	50/50d	4.5	1.77	3.97	4.58	5.26	6.26
11	50/50e	5.0	1.83	3.24	4.38	2.26	5.50
12	**45/55a –Control**	**0**	**1.32**	**1.43**	**1.60**	**1.79**	**2.07**
13	45/55b	0.5	5.07	**6.75**	4.86	5.95	8.97
14	45/55c	1.5	**5.24**	5.23	7.14	5.55	7.63
15	45/55d	2.5	3.61	2.89	**9.75**	**9.11**	**9.28**
16	45/55e	3.5	2.37	3.44	4.25	4.13	5.66
17	45/55f	4.5	3.01	2.93	4.18	4.18	4.02
18	45/55g	5.0	2.62	3.34	4.42	4.33	4.79

Table 4 presents the compressive strength results of the PC, 55/45, 50/50 and 45/55 FHA/CCW binders first as controls then added with NSP. The controls are highlighted in the Table (S/N. 1, 2, 7 & 12).

From the results, the 55/45a FHA/CCW binder had 3 days compressive strength of 1.22 N/mm^2 but 28 days of age with a strength value of 1.71 N/mm^2. This represents a total development of 28.65% from 3 days of age to 28 days of age. These values are extremely low if consideration for their usage as mortar is to be made.

The 50/50a FHA/CCW binder compressive strength result at 3 days of age as low as 0.87 N/mm^2 and 1.16 N/mm^2 at 28 days. The 45/55a FHA/CCW binder on the other hand gave a compressive strength of 1.32 N/mm^2 at 3 days and peaked at 28 days with a strength value of 2.07 N/mm^2. The 50/50a combination though improved by about 25% during the entire duration of strength development from 3 days to 28 days, the 3 days and 28 days strength values were found to be very low compared to the 45/55a combination. The 45/55a binder gave results that were better than the first two binders, but the results were still very low.

After the NSP addition, there was an improvement in the compressive strength of all the mixes. There were total of seven (7) trial percentages of NSP addition in all, they are: 0.5%, 1.5%, 2.5%, 3.0%, 3.5%, 4.5% and 5.0%. The NSP content addition that gave the best result for the 45/55 FHA/CCW is the 2.5% which yielded a compressive strength value of 9.75 N/mm^2 at 14 days. The compressive strength value of the 45/55 FHA/CCW without NSP at the same age was found to be 1.60 N/mm^2. Values of the 45/55 combination's general performance are presented in Table 4.

The 45/55 FHA/CCW binder produced the best result generally, although its early strength of 3 and 7 days was found to be poor compared to the other percentages. This is because, the best compressive strength result of the 45/55 FHA/CCW plus NSP at 3 days was that of the 1.5% NSP content which gave a compressive strength value of 5.24 N/mm^2, this result is 62.86% lower than the corresponding CEM II control at the same age which was found to be 14.11 N/mm^2.

After 14 days of curing, the best performed of the 45/55 FHA/CCW + NSP was that with 2.5% NSP found to be 9.75 N/mm^2. This result is 58.17% lower compared to the corresponding CEM II control at the same age which was found to be 23.31 N/mm^2. The 45/55 binder also produced both the 21 days and at 28 days best compressive strength values of the entire experiment which were found to be 9.11 N/mm^2 and 9.28 N/mm^2, representing 66.30% and 66.58% lower compared to the corresponding CEM II control at both 21- and 28-days age which was found to be 27.03 N/mm^2 and 27.77 N/mm^2 respectively.

Summary of Findings

The following were the major findings of the study:

1. Chemical analysis of the FHA revealed that the ash contained 85.6% SiO_2, 3.58% Fe_2O_3, 8.1% CaO, and 2.01% MgO. Other elements were present in the ash at very insignificant quantities.
2. Oxide composition of the CCW revealed that 82.6% CaO, 2.3% SiO_2, 2.19% Al_2O_3 and 8.51% Carbon. Other minor compounds were found to be very insignificant.
3. The study revealed tremendous improvement in the hydration process as there was reduced final setting times for all three combinations of FHA/CCW when NSP addition. The 40/60 with NSP saved up to 65 minutes (i.e., 29%) savings in the duration of final setting of the combination. The 50/50 with NSP also saved up to 70 minutes (also, 29%) savings in the duration of final setting of the combination and finally the 45/55 with NSP saved up to 75 minutes (i.e., 37%) savings in the duration of final setting of the binder combinations. The experiment produced a general average savings of 31.7% in final setting time which indicates that NSP addition saved close to one third (1/3) of time during the hydration process of the materials.
4. Compressive strength results of the combinations without NSP were found to be very low, with the best performed having 2.07 N/mm^2 as 28 days strength of the 45/55 combination. However, after the addition of NSP, there was a boost in all the cubes crushed for all three combinations. The best performed for the 40/60 combination with 5% NSP with average increase of 57.6%. The 50/50 combination with 4.5% NSP gave average increase of 321.4%, while 45/55 combination with 2.5% NSP has average increase of 308.2%.

The general average increase (in percentage) after addition of NSP to the binder combinations was found to be 229.1%. This shows that the effect of NSP on both hydration and strength improvement cannot be over emphasized as can be seen from the results of this study.

References

American Society for Testing Materials, ASTM C618 - 19 (2018) Standard specification for Coal Fly-Ash and Raw or Calcined Natural Pozzolana for use in Concrete. ASTM International, Philadelphia, PA, 2018. Book of Standards, 04.01.

British Standards BS EN – 196 – 1 – 2016, Methods of Testing Cement. Determination of Strength of Mortar and Concrete. BSI.

Environmental Impact Assessment EIA (2011). Emissions of greenhouse gases in the U.S. 2006 – Carbon Dioxide Emissions; accessed, 2011. 05-23 at the wayback machine.

Gupta, A.I & Wayal, A. S. (2015). Use of Rice Husk Ash in Concrete: A Review. Journal Of Mechanical and Civil Engineering. 12(4), 29-31.

Gupta, Y. P. (2014). Concrete Technology and Good Construction Practices. New Age International Publishers Limited, New Delhi, 16-67.

Horpibulsuk, S., Phetchuay, C. & Chinkulkijniwat, A. (2011). Soil Stabilization by Calcium Carbide Residue and Fly Ash. Journal Of Materials in Civil Engineering, 24 (2), 184 – 193

Jagadish, K.S., Venkatarama, R. B.V. & Nanjunda, R. K.S. (2015). Alternative building materials and Technologies. New Age International Publishers; 2015. 88-107.

Jatturapitakkul, C. & Roongreung B. (2003). Cementing Material from Calcium Carbide Residue – Rice Husk Ash. Journal of Materials in Civil Engineering, 15(5), 470-475.

Makaratat, N., Jaturapitakkul, C. and Laosamathikul, T. (2010). Effect of calcium carbide residue fly ash binder on maechanical properties of concrete. Journal of Materials in Civil Engineering; 22(11), 1164-1170.

Matawal, S.D. (2012). Role of Ordinary Portland Cement in Curbing the Incidences of Building Collapse in Nigeria. National Workshop on Building Collapse in Nigeria, Abuja, Nigeria. 15th -16th May, 2012.

Mehta, P. K. and Monteiro, J. M. (2014). Concrete: Microstructure, Properties, and Materials Fifth Edition; McGraw – Hill Education, 338 Euston Road, London. 1- 89.

Narender, A. R & Meena T. (2017). A Comprehensive Overview on Performance of Nano Silica Concrete; International Journal of Pharmacy and Technology; 9 (1), 5518 – 5529

Nattapong, M., Chai, J. & Thanapol, L. (2010). Effects of Calcium Carbide Residue –Fly Ash Binder on Mechanical Properties of Concrete. Journal of Materials in Engineering, 14(44), 1164 – 1170.

Neville A.M. (2013). Properties of Concrete, (5thedition); Pearson Education Limited, Edinburgh Gate, Harlow England. 58-661.

Ndububa, E.E., Okonkwo, J.S. & Ndububa, O.I. (2016). The Potential Use of Fonio Husk Ash As a Pozzolana in Concrete. Nigerian Journal of Technology (NIJOTECH), Faculty of Engineering, University of Nigeria, Nsukka. 35(1), 31-36.

NIS: 444 – 1: 2003 Nigerian Standards for Construction Materials and Building Manufacturing Engineering: Cement Standards and Application in Nigeria.

Olawuyi, B.J., Joshua, O., Hassan, I.O., Enejiyon, M.O. & Egwuda, C. I. (2017). Exploratory Study on Agro-Waste Ashes Combination with Industrial Waste as Alternative Binders in Concrete, Proceeding of Nigerian Building and Road Research Institute; International Conference on Emerging Materials and Technologies for Sustainable Building & Road Infrastructure, NAF Conference Centre, Abuja, 20 – 22nd June, 2017; 21.

Premium times Newspaper of Nigeria of 25th January, 2023. Accessed online on https://www.premiumtimes.ng.com on 30th January, 2023.

Saurabh, K. S. (2016). Building Materials and Construction, S. K. Kataria and Sons, New Delhi - 110002, India. 93 – 145.

Vichan, S. & Rachan, R. (2013). Chemical stabilization of soft Bangkok clay using the blend of calcium carbide residue and biomass ash. Soils and Foundations, 53, (2), 272 – 281.

Yu chen, Yi-fan D. & Meng-qiang L. (2016). Influence of NanoSiO2 on The Consistency, Setting Time, Early-age Strength and Shrinkage of Composite Cement Pastes; Advances in Materials Science and Engineering. Special Issue; accessed online at https://www.hindawi.com on 22nd February, 2021.

Yunusa, S. A. (2015). Investigation into the use of Calcium carbide waste as a partial replacement of cement in concrete. International Journal of Engineering and Management Research, 5 (2), 675 – 680.

Investigating the Adoption Level of Building Information Modelling for Post-Construction Management in Nigeria

Bello, A. O.[1a] & Ayegba, C.[1b]
[1] Department of Building, School of Environmental Technology, Federal University of Technology, Minna
[a]abdulkabiropeyemi@gmail.com; [b]calistus.ayegba@futminna.edu.ng
Corresponding author: abdulkabiropeyemi@gmail.com

Abstract

The construction industry is often criticized for its reluctance to change and low productivity. However, Building Information Modelling (BIM) has been proposed as a solution to mitigate these challenges. While BIM has been widely adopted during the planning, design, and construction phases of projects, its adoption in the post-construction phase remains limited. This is a critical phase where up to 80% of the total life cycle cost of a facility is expended. This study aimed to investigate the adoption level of BIM for Post-Construction Management (PCM) in Nigeria, using a quantitative research method with 132 International Facility Management Association (IFMA) professionals as respondents. The study found that there is a high level of awareness of BIM for PCM among respondents, with 84% indicating a high and higher level of awareness. However, the usage of BIM-compliant software was very low, with limited proficiency in its use. This high level of awareness is a positive factor that could facilitate rapid adoption of BIM for PCM. Conversely, low awareness could result in slower adoption. Despite the high level of awareness, the adoption level of BIM for PCM remain very low. The study suggests that further efforts are needed to bridge the gap between awareness and adoption, including improving proficiency in BIM-compliant software and creating incentives for its use. Overall, the study highlights the importance of BIM for PCM and the need to increase its adoption in the construction industry.

Keywords: Keywords: Adoption, Awareness, BIM, Level, Post-Construction Management.

Introduction

According to World Economic Forum (2018) the construction industry contributes about 6% to the world Gross Domestic Product (GDP), similar the construction industry is expected to contribute about 15% to the world GDP by the year 2030 (Olanrewaju *et al*., 2021). In the first quarter of 2021, the National Bureau of Statistics report, the industry accounts for 10.17% of the nominal GDP. Consequently, the construction industry is paramount to the development of nations globally. The construction industry is slow in adoption and transitioning from the conventional to a digitalized method of operation by application of technological tools which their application can increase productivity in the construction industry. According to Olorunfemi *et al*. (2021), an increase in new technological tools and applications has led to a paradigm shift in the method of operation from traditional to digitalized around the world.

Although the construction industry is regarded as a major contributor globally, the industry is faced with challenges relating to productivity due to the slow adoption and application of technologies such as BIM (Acre and Wyckmans, 2015), IoT (Ghosh *et al.*, 2021), Industry 4.0 (Newman *et al.*, 2020) and Blockchain (Parn and Edwards, 2019). Adoption of BIM software can ensure improvement in the facility life cycle and adequate data management (Olanrewaju *et al*., 2021; Chioma *et al*., 2020; Aka *et al*., 2020). Despite BIM technology has been adequately adopted during the planning, design and construction phase of the project, it is still considered to be at the early stage of adoption for managing post-construction activities to ensure the facility performs optimally all through its life cycle after completion (Olanrewaju *et al*., 2021).

According to Mohandes *et al*. (2014), PCM is the management of facility assets and maintenance after the design and construction phases have been completed. The American Institute of Architects considers the benefits of BIM lie in the post-construction phase of the project life cycle (AIA, 2015). Even though the major benefits of BIM lie more in the post-construction phase of the project, the level of awareness and adoption is still very low as indicated by various studies (Bello *et al*., 2022; Durdyev *et al*., 2021).

The post-construction activities have usually been managed manually which brings about a waste of time and resources. According to Anton and Diaz (2014) data are erroneously entered repeatedly up to seven times when entered manually, also resulting in poor quality documentation (Jylha and Suvanto, 2015) resulting in handing over delay (Wu and Issa, 2012). Real life can be traced to the United States, where almost $11 billion is lost annually due to inefficient operation of facilities which is worth giving urgent attention to (Arayici *et al*. 2012). In a related study by Hu *et al*. (2018) annual costs through waste caused by operating issues from inaccurate information and interoperability were reported as $10.6 billion in the United States. These cases among others bring about the need to carry out studies in the context of developing countries.

The awareness and level of adoption of BIM for PCM are reasonably high in the developed nations, however, in developing countries, the case is not the same as only south Africa is the only country that has fairly and leading in the adoption of BIM for PCM (Chioma *et al*., 2020). Olanrewaju *et al*. (2021) indicated that sub-Saharan countries like Nigeria are lacking behind in the adoption of BIM for PCM, this basis was further supported by (Olapade and Ekemode, 2018)

This study investigates the adoption level of BIM for PCM in Nigeria using Abuja as the study area which is considered as one of the cities experiencing high rate of modern construction in Nigeria. The study set four distinct objectives to; determine the level of awareness of BIM for post-construction management; determine the usage level of BIM-compliant software among the professionals, determine the level of BIM-compliant software's proficiency among the respondents and established the level of adoption of BIM for post construction management in Nigeria. The outcome of the study will adequately provide insight into the BIM-post-construction management adoption in Nigeria's construction industry and provides the stakeholders with the requisite information about BIM-post-construction management to make informed decisions towards the adoption of BIM for post-construction management.

2.0 BIM Adoption in the Construction Industry

Although BIM adoption is expanding in most developed countries, it is stagnating in most developing countries, such as Nigeria (Chioma *et al*., 2020). BIM is a cutting-edge technology that enables the parameterised expression and integrated management of various data kinds throughout a facility's lifecycle (Eastman *et al*., 2011). During the information management process in the facility lifecycle, BIM technology has transformed the conventional construction industry's development mode, assisting in resolving difficulties such as work coordination and information integration (Hamma-Adama, 2020). As a result, BIM is regarded mainly as a transformative tool for the construction industry and enhancing project management efficiency (Cao, 2016: Ayegba and Root, 2018).

Using BIM technology in construction projects can save up to 40% on unnecessary budgetary modifications, reduce construction time by 7%, save 10% to 17% on operating costs, and reduce greenhouse gas emissions by 50%. (Boston Consulting Group, 2016; World Economic Forum, 2016). BIM can be adopted in the post-construction phase for restorations, space planning, and maintenance functions (Azhar, 2011). A study was conducted by Ikediashi and Uyanga (2016) to better understand the current state of BIM adoption for facilities management roles in Nigeria, with the goal of better understanding the current level of use and efficacy in facilities management service delivery established low usage level and lifecycle cost reduction and on-time service delivery were significantly impacted by the implementation of BIM for facilities management applications.

In a related study by Olapade and Ekemode (2018), just two (2) of the thirty-seven (37) facility management firms examined on their awareness and use of BIM for facility management practices are currently implementing BIM for their operations, indicating a low level of BIM for facility management adoption in Lagos. The findings of this study offered information on the level of understanding and use of BIM for facility management practice in Nigeria, allowing industry stakeholders to gain insight into the possible full integration with facility management practices in developing countries. The research is a ground-breaking investigation of the use of BIM for facilities management awareness and implementation in a rapidly growing property market like Nigeria.

Traditional PCM is inefficient because of the wide time range, extended durations, multiple items, and sophisticated employees involved. In PCM, BIM technology can not only meet user's basic activity needs and increase investment income, but it can also enable information sharing between design, construction, and operations and maintenance, improve information accuracy, and provide a convenient management platform for all participants to enhance the efficiency of building facility management (Wang, 2015). In terms of BIM's application in PCM, Akcamete *et al*. (2010) discovered that maintenance costs account for more than 60% of total project costs. BIM can practically visualise many aspects of facility management in real time. Data can be stored in the BIM model indefinitely and studied from various angles to enhance PCM tasks.

Several researchers have demonstrated the potential of BIM in PCM, and they agree that the early application of BIM in the operation and maintenance phase included seven aspects of BIM: maintenance and repair, change management, space management, emergency management, security management, energy management, and asset management (Gao and Pishdad-Bozorgi, 2019). The literature reviewed argues for the embrace of innovation, particularly BIM innovation, for the sector to survive. In the construction industry, BIM has been innovative, and its adoption needs a streamlined approach. As this is a novel paradigm, investigation methods are continually emerging. There is limited study on BIM in the researched country significantly, outside of a single field and possibly cities (Hamma-Adama, 2020). More than three-quarters of the published literature on BIM studies in Nigeria such as (Abubakar *et al*., 2014; Ugochukwu *et al*., 2015) identified a fundamental barrier to BIM adoption as a lack of knowledgeable personnel in the technology. And more than half of them is due to a lack of knowledge and understanding of the technology's potential.

Methodology

This study adopts a quantitative method to carry out the research by collecting data from IFMA professionals in Abuja. A questionnaire was adopted as the method of data collection which was based on the five Likert scales. The research population are registered IFMA members in Abuja, and at the time of data collection for this study, the total number of registered IFMA members stands at 207. Since the total population is known, the study adopts a probability sampling technique using a simple random technique. The sample size is calculated below using the using Yamani's (2013) formula below and adopts a 95% level of confidence at 0.05.

$$n = \frac{N}{1+N(e)^2} \qquad (1)$$

Where n = sample size

N = population size (207)

e = acceptable sampling error (0.05)

Adopting this formula, the sample size outcome is 135 which indicates the number is sufficient enough for this study.

A total number of 164 questionnaires were distributed among the 207 professionals, and 148 were retrieved during data collection. Two distinct criteria were set to select valid responses; any unanswered question and if more than one answer is provided for one question. Based on these criteria 16 responses were considered unfit for the study, hence the study considers 132 valid responses. The data were presented in table and charts for easy understanding.

Result And Discussion

Characteristics of the Respondents

A five-sectioned questionnaire was presented to the respondents based on five Likert scales. Among the 207 IFMA registered professionals in Abuja, the questionnaire was administered to 164, and 148 questionnaires were retrieved during collection. 132 questionnaire was properly filled and considered for the study. The number of respondents considered in this study is found adequate compared to previous related studies (Olanrewaju *et al.*,2020; Chioma *et al.*, 2020). Table 1 presents the characteristics of respondents according to their academic qualification, profession, age group, gender, registration with IFMA, years of experience, client type and size of the firm. Academic qualification: The academic qualification of the respondents shows that 6.82% hold a Higher National Diploma, 4.55% hold a Post Graduate Diploma, 46.97% hold a bachelor's degree, 36.36% hold a master's degree and 5.30% hold a doctor of philosophy. Professional Background: Among the respondents, 6.06% were Architect, 25% were Builder, 12.88% were Engineer, 44.70% were Estate Surveyor, 0.76% were Project Managers and 10.61% were Quantity Surveyor.

The years of respondents have been a registered member of IFMA shows that 4.55% have been a registered member for less than 5 years, 43.18% have been a registered member for 5-10 years, 37.12% have been a registered member for 10-15 years, 9.85% have been registered for 15-20 years and 5.30% have been registered for 20 years above.

Table 1: Characteristics of the Respondents

Variable		**Frequency**	**Percentage (%)**
Academic Qualification	Bachelor Degree	62	46.97
	Doctorate Degree	7	5.30
	Higher National Diploma	9	6.82
	Master Degree	48	36.36
	Post Graduate Diploma	6	4.55
	Total	**132**	**100.00**
Profession	Architect	8	6.06
	Builder	33	25.00
	Engineer	17	12.88
	Estate Surveyor	59	44.70
	Project Manager	1	0.76
	Quantity Surveyor	14	10.61
	Total	**132**	**100.00**
Registration with IFMA	Less than 5 years	6	4.55
	5-10 years	57	43.18
	10-15 years	49	37.12
	15-10 years	1	0.76
	15-20 years	12	9.09
	20 years Above	7	5.30
	Total	**132**	**100**
Years of Experience	Less than 5 years	4	3.03
	5-10 years	49	37.12
	10-15 years	56	42.42
	15-10 years	1	0.76
	15-20 years	12	9.09
	20 years Above	10	7.58
	Total	**132**	**100.00**
Client Type	Government	39	29.55
	Private	93	70.45
	Total	**132**	**100.00**
Size of Firm	Large (250 Above)	6	4.55
	Medium (50-249)	59	44.70
	Small (10-49)	67	50.76
	Total	**132**	**100.00**

The respondent working experience shows that 3.03% of the respondent has been working for less than 5 years, 37.12% have been working for 5-10 years, 42.42% has between 10-15 years of working experience, 9.85% has between 15-20 years working experience and 7.85% has 20 years above working experience. The result shows 29.55% of the respondents work in a government establishment while

70.45% work in a private establishment. The result shows that 4.55% of the respondent works in a large firm (250 above), 44.70% works in a medium firm (50-249) and 50.76% works in a small firm.

Awareness Level of BIM for Post-Construction Management

Figure 1 show the awareness level of respondents of BIM for PCM ranging from very high to very low. Respondents were asked to select based on their level of awareness on a scale of (*5 = Very High, 4 = High, 3 = Moderate, 2=Low, 1 = Very Low).* The result shows that the majority of the respondents are aware of the usage of BIM for PCM and none of them is unaware of BIM usage for PCM with 53.03% awareness level being very high, 31.06% high, 12.88% moderate and 3.03% low. According to Nicał and Wodyński (2016), the basis of appreciating a BIM-enabled process in the application of BIM for post-construction is to create awareness among the stakeholders. Studies in the context of developing nations like Nigeria (Babatunde *et al*., 2020; Gamil and Rahman, 2019) and other developing nations Khoshfetrat *et al*. (2020) have all established lack of awareness of BIM as a major challenge.

A related study by Olapade and Ekemode (2018) using Lagos as a case study, established that awareness of BIM among facility management professionals is low. Also, (Bello *et al*., 2022; Olanrewaju *et al*., 2020) reported a low level of awareness of BIM at the operation stage in the Nigerian construction industry.

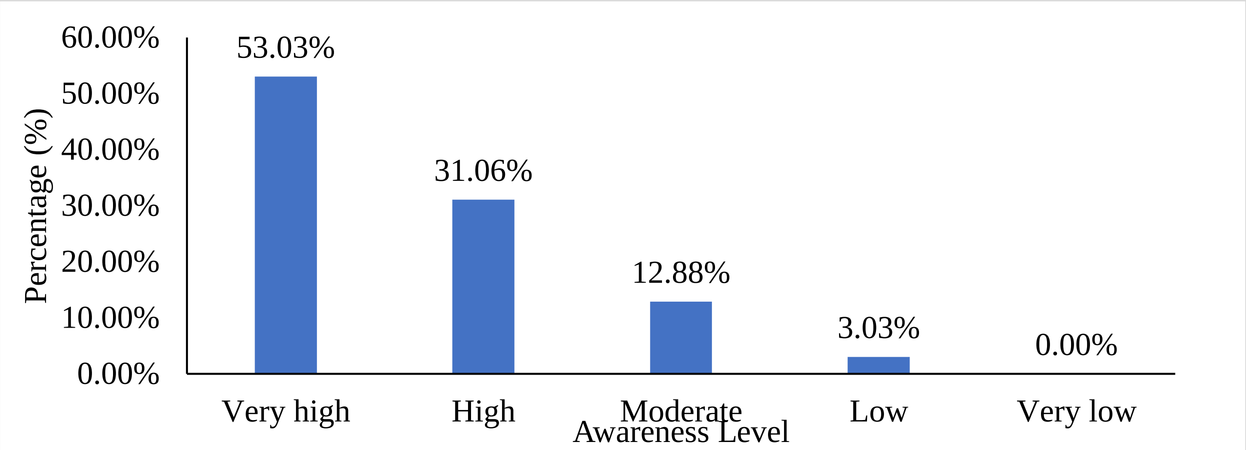


Figure 1 Awareness Level of BIM for Post-Construction Management

A similar study by Ogunmakinde and Umeh (2018) established that awareness of BIM has been rapidly growing in the Nigerian built environment industry but the understanding of the full concept is still found to be lacking among Nigerian built environment professionals. Hence, this study establishes there is now a high level of awareness of BIM for the PCM of the facility, which negates previous literature establishing a lack of awareness. However, despite the promising results on awareness of BIM for PCM in the Nigerian construction industry, there is a paramount need to transform the awareness into usage and implementation of BIM for PCM which is the most essential stage of the project lifecycle.

Usage Level of BIM-Compliant Software for Post-Construction Management

Table 2 shows the result on the usage level of some selected BIM-compliant software's for PCM. The respondents were asked to select as appropriate on a scale of (5 = *Almost Always, 4 = Sometimes, 3 = Not sure, 2 = Rarely and 1 = Not at all*) based on their level of usage. Table 2 show the result for data reliability test, reliability test is necessary to determine if the collected data is reliable and suitable for analysis. According to rule of thumb of Maree and Pietersen (2016) on interpreting Cronbach's alpha coefficient, value of 0.90 is considered strongly reliable, 0.80 is considered moderately reliable and 0.70 is considered low reliable. Based on the reliability value (0.806) show in Table 2 indicates the data for this study is reliable and suitable for analysis.

The result shows that the software's are practically not in use in Abuja by the IFMA professionals. The mean score ranges between 1.136 to 1.000 as shown in Table 3. Similarly, Table 4 shows the scale measurement for the mean as relate to table 4.3. Only seven software's have mean value higher than 1.000 which ranges from "BIM 360" (mean = 1.136; SD = 0.442; Var = 0.195) to "usBIM.facility"(mean = 1.008; SD = 0.087; Var = 0.008). Considering the scale measurement all the mean value in Table 3 fall under the scale of 0.00-1.49 which represent "not at all" level of usage. It can then be established that BIM compliant software's are not in use by the professionals.

This study established that the conventional methods are practically still in use by the professionals in Abuja to provide guidance and operate the buildings during the post-construction stage of the facilities leaving numerous benefits of BIM untapped at the post-construction stage. It is advantageous to adopt tools such as BIM to foster the performance of facilities in the post-construction phase. As stated by Faltejsek and Chudikova (2019) lifecycle of facilities requires to be maintained to foster operation at the maximum level for end users throughout the lifecycle of the building.

Table 2: Test for Data Reliability

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.806	0.858	7

Table3: Mean ranking of the identified BIM-software's for PCM

BIM-Compliant Software	**Mean**	**N**	**SD**	**Min**	**Max**	**Var**
BIM 360	1.136	132	0.442	1.000	4.000	0.195
BIMCOLLAB	1.030	132	0.245	1.000	3.000	0.060
BIMOBJECTS	1.030	132	0.348	1.000	5.000	0.121
BIM TRACK	1.030	132	0.275	1.000	4.000	0.075
LOAD PLANNER	1.023	132	0.261	1.000	4.000	0.068
REVIZTO	1.015	132	0.123	1.000	2.000	0.015
usBIM.facility	1.008	132	0.087	1.000	2.000	0.008
ECODOMUS	1.000	132	0.000	1.000	1.000	0.000
ONUMA	1.000	132	0.000	1.000	1.000	0.000
ARCHIBUS	1.000	132	0.000	1.000	1.000	0.000
YOUBIM	1.000	132	0.000	1.000	1.000	0.000
VUEOPS	1.000	132	0.000	1.000	1.000	0.000
AVAIL	1.000	132	0.000	1.000	1.000	0.000
BIMandCO	1.000	132	0.000	1.000	1.000	0.000
SEFAIRA	1.000	132	0.000	1.000	1.000	0.000
GREEN BUILDING STUDIO	1.000	132	0.000	1.000	1.000	0.000
LADYBUG	1.000	132	0.000	1.000	1.000	0.000
TRIMBLE CONNECT	1.000	132	0.000	1.000	1.000	0.000
ALLPLAN BIMPLUS	1.000	132	0.000	1.000	1.000	0.000
DROFUS	1.000	132	0.000	1.000	1.000	0.000

Note: SD = Standard Deviation: Var = Variance

Table 4: Scale Measurement for Mean

Scale	**Mean**	**Decision**
5	4.50 to 5.00	Almost Always
4	3.50 to 4.49	Sometimes
3	2.50 to 3.49	Not sure
2	1.50 to 2.49	Rarely
1	0.00 to 1.49	Not at all

This study further establishes a low level of BIM adoption for post-construction management concerning previous studies (Durdyev *et al*., 2021; Chioma *et al*., 2020; Olanrewaju *et al*., 2020; Ademci and Gundes, 2018; Olapade and Ekemode, 2018; Ikediashi and Uyanga, 2016; Akcamete *et al*., 2010).

Level of BIM Adoption for Post-Construction Management

Figure 2 shows the result when the respondent was asked to indicate the adoption level of BIM for PCM. Respondents were asked to select based on their level of agreement on a scale of (*5 = Very High, 4 = High, 3 = Moderate, 2=Low, 1 = Very Low).* The majority of the respondents are of opinion that the adoption level of BIM for post-construction management in Abuja is on the low side, as none of the respondents considered the adoption to be very high or high, 2.27% considered it as moderately adopted, 72.73% considered the adoption is low and 25.00% considered the adoption level to be very low.

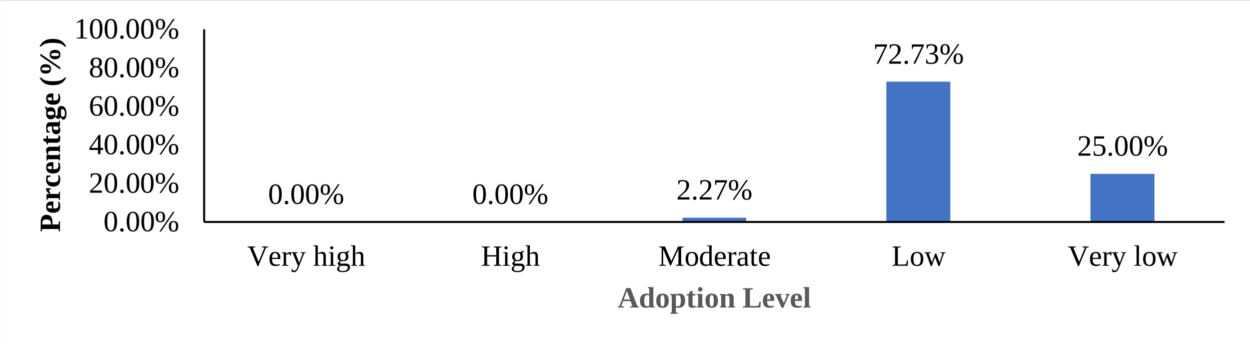


Figure 2: Level of BIM Adoption for PCM

This result further corresponds with table 4.3 investigating the usage level of BIM-compliant software's for PCM. This study establishes that there is low adoption of BIM for PCM in Abuja which is in line with and backed by the previous related studies (Bello *et* al., 2022; Durdyev *et al*., 2021; Chioma *et al*., 2020; Olanrewaju *et al*., 2020; Ademci and Gundes, 2018; Olapade and Ekemode, 2018; Ikediashi and Uyanga, 2016; Akcamete *et al*., 2010). Further, since BIM compliant software's are not in use, it explains the reason why the proficiency level is lacking among the professionals.

Conclusion And Recommendation

Conclusion

Generally, the adoption of BIM is low in developing countries, especially African nations which are considered the only continent that has not maximized the benefits of BIM. However, its adoption at PCM of the facility is lacking and almost not appearing. In the context of Nigeria where previous studies have established a low level of awareness for PCM in the construction industry, this study established that currently there is a high awareness level of BIM for PCM among professionals. Despite the high level of awareness of BIM for PCM, its adoption and implementation are low among the industry professionals as they are all still operating traditionally (manually). As indicated in the findings of the study, usage of BIM-compliant software's is insignificant which then interprets low adoption and implementation. Consequently, this study contributes to the literature indicating a low awareness level of BIM for PCM. This study set out four objectives which were adequately discussed based on the valid responses considered for the study which contribute to the body of literature and will be of benefit to both industry and academia.

Recommendation

This study recommends the construction industry stakeholders should encourage flexibility towards the adoption of new technologies to ease operations which will in turn bring about mitigating productivity challenges which have been ravaging the industry. Various organizations should encourage and provide training on BIM for PCM for their employees to increase the adoption, usage and proficiency of the BIM software's. Higher institutions offering construction-related courses should include BIM courses in their respective curriculum, this will create more awareness from the grassroots and rapid rate of experts in the handling of BIM software's. Governments have been a major driving force towards ensuring BIM is adequately adopted and implemented in developed countries, this approach is recommended to be emulated in developing countries to foster the adoption of BIM software's.

REFERENCES

Abubakar, M., Ibrahim, Y. M., Kado, D., and Bala, K. (2014). Contractors' perception of the factors affecting Building Information Modelling (BIM) adoption in the Nigerian Construction Industry. *International Conference Computing in civil and building engineering,*167-178.

Acre, F., and Wyckmans, A. J. S. (2015). The impact of dwelling renovation on spatial quality: The case of the Arlequin neighbourhood in Grenoble, France, *Smart Sustain. Built Environment*, 4(3), 268-309.

Ademci, E., and Gundes, S. (2018). Review of studies on BIM adoption in AEC industry. *5th International Project and Construction Management Conference (IPCMC) Proceedings*, 1046-1055.

AIA Trust (2015). New Processes, Tools, and Technologies: BIM to IPD, (available online http://www.theaiatrust.com/whitepapers/sustainable/processes.htm (accessed February 12, 2022).

Aka, A., Iji, J., Isa, R. B., and Bamgbade, A. A. (2021). Assessing the relationships between underlying strategies for effective building information modeling (BIM) implementation in Nigeria construction industry. *Architectural Engineering and Design Management*, *17*(5–6), 434–446.

Akcamete A, Akinci B, and Garrett H. J. (2010). Potential utilization of building information models for planning maintenance activities. *Computing Civil and Building Engineering Proceedings of the International Conference*, 1(6), 151-165.

Akerele, A. and Etiene, M. (2016). Assessment of the level of awareness and limitations on the use of building information modeling in Lagos state, *International Journal of Scientific and Research Publications*, 6(2), 229-234.

Anton, L. Á., and Díaz, J. (2014). Integration of life cycle assessment in a BIM environment. *Procedia Engineering*, *85*, 26-32.

Arayici, Y., Onyenobi, T. and Egbu, C. (2012). Building information modelling (BIM) for facilities management (FM): the media city case study approach, *International Journal of 3-D*, 2(4), 28-42

Ayegba, C. and Root, D., (2018). "Procurement Tactics for Selecting Suitable Contractors for Collaboration and Long-Term Relationships" A Productive Relationship: Balancing Fragmentation and Integration. *Presented at the Proceedings of the 34th Annual ARCOM Conference*, Belfast, UK, ARCOM, London, UK, 72-81

Azhar, S., Khalfan, M., and Maqsood, T. (2011). Building information modelling (BIM): Now and beyond, Australasian. *Journal of Construction Economics and Building*, 7, 15–28.

Babatunde, S. O., Ekundayo, D., Adekunle, A. O. and Bello, W. (2020). Comparative analysis of drivers to BIM adoption among AEC firms in developing countries: a case of Nigeria, *Journal of Engineering, Design and Technology*, 18(6), doi: 10.1108/JEDT-08-2019-0217.

Bello, A. O., Ayegba, C., Olanrewaju, I. O., Afolabi, O., and Ihedigbo, K. S. (2022). A Review on the Awareness and Challenges of Building Information Modelling for Post Construction Management in the Nigerian Construction Industry. *5th International African Conference on Current Studies*, 137–142.

Boston Consulting Group (2016). *Digital in Engineering and Construction: The Transformative Power of Building Information Modeling*, Boston Consulting Group, Boston, MA, USA.

Cao, D., Li, H., Wang, G., Huang, T. (2016). Identifying and contextualising the motivations for BIM implementation in construction projects: *An empirical study in China, International Journal of Project Management*, http://dx.doi.org/10.1016/j. ijproman.2016.02.002.

Chioma, O., Innocent, M., and Andre, K. (2020). Identifying motivators and challenges to BIM implementation among facilities managers in Johannesburg, South Africa. *September*, 104–110. https://doi.org/10.3311/ccc2020-028

Durdyev, S., Ashour, M., Connelly, S., Mahdiyar, A. (2021). Barriers to the implementation of Building Information Modelling (BIM) for facility management, *Journal of Building Engineering* (2021), doi: https://doi.org/10.1016/j.jobe.2021.103736. 84, 195–206.

Eastman, C., Teicholz, P., Sacks, R. and Liston, K. (2011). BIM Handbook: A Guide to building information modeling for owners, managers, Designers, Engineers, and Contractors, John Wiley and Sons Inc, New Jersey, USA.

Faltejsek, M. and Chudikova, B. (2019). Facility management and building information modelling during operation and maintenance, M*ATEC Web of Conferences*, 277, 2022.

Gamil, Y. and Rahman, I.A.R. (2019). Awareness and challenges of building information modelling (BIM) implementation in the Yemen construction industry, *Journal of Engineering, Design and Technology*, 17(5), 1077-1084.

Gao, X., and Pishdad-Bozorgi, P. (2019). BIM-enabled facilities operation and maintenance: A review. *Advanced engineering informatics*, *39*, 227-247.

Ghosh, A., Edwards, D.J. and Hosseini, M.R. (2021), Patterns and trends in Internet of Things (IoT) research: future applications in the construction industry, Engineering, Construction and Architectural Management, 28(2), 457-481.

Hamma-Adama, M. (2020). Framework for macro building information modelling (BIM) adoption in Nigeria. Robert Gordon University, PhD thesis. Hosted on OpenAIR [online]. Available from: https://openair.rgu.ac.uk.

Hu, P. Tian, S. Li, J. Zhang. (2018). BIM-based integrated delivery technologies for intelligent MEP management in the operation and maintenance phase. *Advances in Engineering Software*, 115 (2018) 1–16.

Ikediashi, D., and Uyanga, J. (2016). Adoption of BIM technologies for facilities management roles in Nigeria: An Empirical Investigation. *ICCREM 2016: BIM Application and Offsite Construction - Proceedings of the 2016 International Conference on Construction and Real Estate Management*. https://doi.org/10.1061/9780784480274.001.

Jylha, T. and Suvanto, M.E. (2015), "Impacts of poor quality of information in the facility management field", Facilities, 33 (5), 302-319. https://doi.org/10.1108/F-07-2013-0057

Khoshfetrat, R., Sarvari, H., Chan, D. W. M. and Rakhshanifar, M. (2020). Critical risk factors for implementing building information modelling (BIM): a delphi-based survey, *International Journal of Construction Management*, doi: 10.1080/15623599.2020.1788759.

Li, X., Wu, P., Shen, G. Q., Wang, X., and Teng, Y. (2017). Mapping the knowledge domains of Building Information Modeling (BIM): A bibliometric approach. *Automation in Construction*, *84*, 195-206.

Maree, K., and Pietersen, J. (2016). The quantitative research process, in Maree, K. (Ed.), First Steps in Research, 2nd ed., Paarl Media, South Africa, 161-172

Mohandes, S. R., Preece, C., and Hedayati, A. (2014). Exploiting the effectiveness of building information modeling during the stage of post construction. *Journal of Basic and Applied Scientific Research*, *4*(10), 5-16.

Newman, C., Edwards, D., Martek, I., Lai, J., Thwala, W. D., Rillie, I. (2020). Industry deployment in the construction industry: A bibliometric literature review and UK-based case study, Smart Sustainable. *Built Environment Journal*, 1(2), 25-38.

Nicał, A. K., and Wodyński, W. (2016). Enhancing Facility Management through BIM 6D. *Procedia Engineering*, *164*, 299–306. https://doi.org/10.1016/J.PROENG.2016.11.623

Ogunmakinde, O. E. and Umeh, S. (2018). Adoption of BIM in the Nigerian architecture engineering and construction (AEC) industry, *Paper presented at the 42nd Australasian Universities Building Education Association* (AUBEA).

Olanrewaju, O. I., Chileshe, N., Babarinde, S. A., and Sandanayake, M. (2020). Investigating the barriers to building information modeling (BIM) implementation within the Nigerian construction industry. *Engineering, Construction and Architectural Management*, *27*(10), 2931–2958. https://doi.org/10.1108/ECAM-01-2020-0042

Olanrewaju, O. I., Kineber, A. F., Chileshe, N., Edwards, D. J. (2021). Modelling the impact of building information modelling (BIM) implementation drivers and awareness on project lifecycle. *Sustainability and Engineering Journal*, 13, 88-87. https:// doi.org/10.3390/su13168887.

Olapade, D. T., and Ekemode, B. G. (2018). Awareness and utilisation of building information modelling (BIM) for facility management (FM) in a developing economy: Experience from Lagos, Nigeria. *Journal of Facilities Management*, *16*(4), 387–395. https://doi.org/10.1108/JFM-09-2017-0046.

Olorunfemi, E., Olanrewaju, O., Oyewobi, L., and Olorunfemi, R. (2021). Competencies and the penetration status of building information modelling among built environment professionals in Nigeria. https://www.researchgate.net/publication/352787164

Parn, E.A. and Edwards, D. (2019), "Cyber threats confronting the digital built environment: Common data environment vulnerabilities and block chain deterrence", Engineering, Construction and Architectural Management, 26(2), 245- 266. https://doi.org/10.1108/ECAM-03-2018-0101

Ugochukwu, S.C., Akabogu, S.C., and Okolie, K.C. (2015). Status and perceptions of the application of building information modelling for improved building projects delivery in Nigeria. American Journal of Engineering Research, 4(11), 176-182.

Wang, C. (2015). Assessment of BIM implementation among MEP firms in Nigeria. *International Journal of Advances in Applied Sciences*, 4(3), 73-81.

World Economic Forum (2016). Shaping the future of construction*: A Breakthrough in Mindset and Technology*, World Economic Forum, Geneva, Switzerland.

World Economic Forum (2018). Shaping the future of construction - Future Scenarios and Implications for the Industry, World Economic Forum, Geneva, Switzerland, available at:http://www3.weforum.org/docs/Future_Scenarios_Implications_Industry_report_2018.pdf (accessed 8 January, 2022).

Wu, W. and Issa, R. R. (2012). BIM-enabled building commissioning and handover.

Yamani, N. A. (2013). *Housing and quality of life implications of the three qualities of housing in Amman*, Jordan. Unpublished PhD Thesis submitted to Cardiff University, School of Planning and Geography

A Study of the Productivity of Permanent Staff and Contract Staff for POP Workers and Tilers in Abuja

Agada, D.A.[1a] & Ayegba, C.[1a]
[1]Federal University of Technology Minna, School of Environmental, Department of Building, Minna, Nigeria.
[a]agadaid@gmail.com:[b]calistus.ayegba@futminna.edu.ng
corresponding author: agadaid@gmail.com

Abstract:

Every country's GDP is greatly impacted by the construction industry (CI). However, concerns have been raised about the low productivity of the construction labor force during both the building and maintenance phases. Construction project's objectives could not be achieved unless labor productivity is raised. The aim of this research work is to study the productivity of Plaster of Paris (POP) workers and tilers for both permanent and contract staff within Abuja in other to advice appropriately the best staffing methods for such craft. Quantitative research methodology was applied with the use of time study to study the productivity of tilers and POP workers for both permanent and contract staff in 10 building sites in Abuja (5 sites for POP workers 5 for tilers). A total of 20 gang was studied for the purpose of this study. Each gang is made of two members. The results were analyzed using a simple arithmetic equation for calculating productivity. The results show mean productivity of the permanent staff POP workers is 1.108hrs/m^2 why that of the contract staff POP workers is 0.945hrs/m^2. The mean productivity of the permanent staff tiler is 1.043hrs/m^2 why that of the contract staff tiler is 0.871hrs/m^2. This implies that the productivity of contract staffs for both POP workers and tilers are better than that of their permanent staff counterparts. Contract staff is therefore advised for both POP activities and tilling activities in Abuja but this must be done without exploitation of the workers.

***Keywords**: Labour Productivity, Contract staff, Permanent staff, POP workers, tilers.*

. Introduction

The construction industry is an important industry for the national economy of any nation as it provides space for other economic activities to take place. (Liu, 2008 and Rabia et al., 2020). The industry is labour intensive comprising physical (human) labour and mechanical (using machine) labour. This human labour usually refers to as labour productivity (Agbo& Ayegba, 2014). Labour productivity is defined as the relationship between output and input (Rao & Sudhanva, 2017; Agboet al 2021). Labour productivity consist of about 30 -50% of the overall cost of project (Jakas & Bita, 2012). Labour productivity determine to a greater extent the profit margin of contractors. Thus, increasing productivity is a crucial priority for any profit-oriented organization (Wilcox, 2000).

One of the key strategies for productivity increment is the quality of personnel. An organization with well qualified personnel has a higher chance of increased productivity (Gopal & Murali, 2015). This implies that in selection and recruitment of employee's emphasis should be on the quality of personnel being selected and recruited into the organization. The quantity and quality of the organization's production are directly impacted when low-quality workers are hired. Getting this quality employee depends so much on the method of recruitment and selection. In the 20th Century, emphasis was on permanent and pensionable employments system which has its disadvantage to the contractors and advantage to the employees (Agbo, 2014). However, in this 21st Century, emphasis has shifted from permanent and pensionable methods to contract and casual employment in the quest to reduce production cost and increase productivity (Mahesh *et al*., 2017).

Concept of Labour Productivity in Construction Industry

Jarosaw *et al*. (2019) develop a mathematical model of construction worker productivity. They did it by grouping 17 elements that influence the productivity of construction workers into five categories. Fuzzy logic was utilized to describe the factors mathematically. A formula for calculating construction worker productivity has been proposed. The authors' approach is unique in that it takes into account a variety of elements that have the ability to influence construction workers' productivity. A single assessment of ceiling formwork was conducted to demonstrate how the formula works. The validation of a model demonstrated that it is capable of accurately analyzing, evaluating, and predicting the productivity of construction employees.

Salehi *et al*. (2013) investigated labour productivity issues using the nearest neighbor algorithm (NNA) to categorize things. To determine the value of items and standardize outputs, a multiple regression approach is utilized, accounting for the labour requirements for standard parts in each category as well as their production processes. A case study was given to verify the viability of the suggested technique. This technique has a number of advantages, including raising labour productivity, bolstering the production system, improving planning, and responding to market volatility.

Methods of Measuring Productivity

Isaac *et al*. (2015) claim that productivity metrics may be analyzed in terms of the entire range of production inputs, including labour as well as natural resources, intermediate commodities, and services. Average labour productivity (ALP), a single factor productivity metric, and total factor productivity, a multi-factor metric, are both used to quantify productivity. The output potential of a manufacturing process in proportion to its inputs is known as productivity (TFP). The impact of one input is measured by single factor productivity, but the influence of all inputs on output is measured by multi-factor or total factor productivity (labour). Tasks are specific construction operations including pouring concrete, installing tiling, and erecting structural steel. According to Isaac *et al*., (2015) task-level productivity measurements are routinely used in the construction industry.

According to Attar *et al*. (2012), the majority of task-level productivity indicators are single factor measures that concentrate on labour productivity. According to Attar *et al*. (2012), contractors are frequently interested in the labour productivity at project sites, which can be categorized in one of two ways:

$$Labour\ Productivity = \frac{Output}{Labour\ Cost} \quad (1)$$

$$Labour\ Productivity = \frac{Output}{Work-hour}.. \quad (2)$$

The study also found that man-hours per unit (unit rate), which is the opposite of labour productivity, is frequently employed and that there is no universally recognized definition or measure of productivity.

Casual or Contract Staff

Employees whose services are contingent on the specific function or responsibility they were recruited to perform are referred to as "contract personnel." They are laid off when their 'contract' expires, and they can only be rehired if another job is available. The fact that their employment is not permanent is the greatest distinguishing feature of this group of workers (Badmus *et al*, 2020).

The word "casualization" refers to occupations that have a high degree of cyclical demand, such as port work, agricultural migratory labour, and other intermittent low-skilled jobs. Another form of involuntary servitude that lasts for a certain period of time is casualization. Labour abuse is pervasive in many Nigerian organizations. There are many instances of this, including low pay, wage and salary arrears systems, training, career progression, motivation, feeling of community, job satisfaction, and dehumanization of work and people. (Badmus *et al*, 2020).

Casualization is another term for temporary employment, which can be found in a variety of industries, including transnational, multinational, public, and private companies, as well as the informal sector. As Campbell and Brosnan (2004) point out, definitions of casual work are frequently a source of misunderstanding and debate, with contradictions between vernacular, regulatory, and contractual meanings.

Permanent or Full-Time Staff

When someone works for an employer and receives their pay directly from them, it is said that they are in a permanent employment relationship. With this kind of work arrangement, the end date is not specified. Part-time or full-time employment, as defined by the Bureau of Labour Statistics as workweeks averaging 35 hours or more, are both options for permanent employees. Benefit packages are typically provided to permanent employees by their employers, though these packages can change depending on whether they work full- or part-time Indeed Editorial Team (2021).

Eight-hour days and 40-hour weeks are the standard for a full-time job, though this depends on the industry and position. The assumption of a five-day workweek varies based on the profession. Full-time employment is not specifically defined by the US Department of Labour; instead, it is up to individual businesses to do so. The idea of "business hours" or "9 to 5" employment gives people a common understanding of full-time employment. Monday through Friday, 9:00 a.m. to 5:00 p.m., are the typical office and corporate culture hours, while there may be some variance based on the company's culture and industry. There are no fixed requirements for when those hours must be completed; nonetheless, full-time employment demands a 40-hour workweek (or at least a schedule of at least 32 hours). Along with some degree of financial security, full-time employees typically get a variety of benefits as part of their employment agreement, such as paid time off (PTO), 401(k) plans, and insurance (Reshetnikova *et al*., 2019).

Considering the various views and studies carried out in these areas so far it is obvious to note that though have being a change from the conventional permanent employment to temporary or contract employment there have being the difficulty of determining the most appropriate staffing methods for these two craft being considered in this research. From preliminary site investigation there have been so much divergent view about which is most appropriate for best productivity and yet not been involved in the 21st form of modern slavery. This necessitates this study to ascertain the most appropriate staffing methods for POP workers and tilers with the view of determine the most appropriate one within the FCT Abuja.

Methodology

The methodology used for collecting data in thus study was through the use of time study administered to POP workers and tilers of both permanent and contract staffs on site. This study was limited to ten building construction sites in Abuja. The gang size used for the purpose of this research for both POP workers and tilers is two. The total number of gangs studied is 20. In carrying out the time study, the following tools are used: a stopwatch, a plane sheet, a pencil, an eraser, clipboards, and a ruler.

Time: The researcher begins work at the site when it opens (7:30 am) and ends when it shuts (3:30 pm), or eight (8) working hours, depending on when the location is visited. In order to see well and to minimize interruptions while doing the study on location, the researcher finds a comfortable spot to sit a little distance from the subject of observation. The following information is included in the used paper:

- Type of work done
- Rating based on observation
- The start time for each type of work done
- The ending time for each type of work done
- The observed time
- The idle time
- The actual time
- Total area of work covered (Attar *et al*., 2012)

When a job is interrupted, the duration of the interruption is noted as idle time. At the end of the day's work, the total amount of idle time is removed from the overall amount of time spent to give us the real amount of time used for that specific activity. By beginning the stop clock as soon as work begins, the observation process starts and is then continued. When work is interrupted, it was ensured that the length of the interruption was precisely documented. This procedure was repeated for different gangs of POP workers and tilers on 10 selected sites (5 for POP worker and 5 for tilers) having both contract and permanent staff on site for 14 days on each site.

Results And Discussions

Table 1 shows the summary of the Labour productivity study carried out using the Time study for POP activity and Tilling activity which were either contract or permanent staff. This study was carried out on 5 building sites having both contract and permanent staff on site working on either tilling or POP work. Table 1 shows the expected mean productivity from each project and the actual mean productivity. It can be observed from table 1 that there is no consistency in the daily productivity of either contract or permanent staff of both the tilers and POP works and this can be caused by so many human factors and atmospheric factors such as; less idle time, the particular work load being assigned for the craft man to do for which he has the liberty to live after the work has been completed and duly inspected without having to wait for the official closing time, the psychological state of the craft man, the zeal to work on such day, weather conditions and many other factors which are being considered further at the course of this research.

The mean productivity of the permanent staff POP workers is 1.108hrs/m^2 why that of the contract staff POP workers is 0.945hrs/m^2, this shows that the permanent staff of POP workers takes 1.108hrs to complete one square meter of POP work why the contract staff takes 0.945hrs to complete the same areas of work, implying that the average productivity of the contract staff is better than that of the permanent staff since it takes the contract staff less time to complete the same square meter of the work.

Table 65: Summary result for labour productivity of POP Activity and Tilling Activity

POP Activity

Project no.	**Permanent staff Expected productivity (hrs/m²)**	**Actual productivity (hrs/m²)**	**Contract staff Expected productivity (hrs/m²)**	**Actual productivity (hrs/m²)**
1.	1.235	1.106	1.235	0.961
2.	1.235	1.096	1.235	0.920
3.	1.235	1.031	1.235	0.893
4.	1.235	1.082	1.235	0.919
5.	1.235	1.224	1.235	1.033
Mean value		**1.108**		**0.945**

Tilling activity

Project no.	**Permanent staff Expected productivity (hrs/m²)**	**Actual productivity (hrs/m²)**	**Contract staff Expected productivity (hrs/m²)**	**Actual productivity (hrs/m²)**
1.	1.108	1.009	1.108	0.864
2.	1.108	1.039	1.108	0.905
3.	1.108	1.146	1.108	0.875
4.	1.108	0.983	1.108	0.896
5.	1.108	1.039	1.108	0.817
Mean value		**1.043**		**0.871**

From Table 1, the mean productivity of the permanent staff tiler is 1.043hrs/m^2 why that of the contract staff tiler is 0.871hrs/m^2, this shows that the permanent staff tiler takes 1.043hrs to complete one square meter of tilling work why the contract staff takes 0.871hrs to complete the same areas of work, implying that the average productivity of the contract staff is better than that of the permanent staff since it takes the contract staff less time to complete the same square meter of the work. It can also be seen from table 1 that the mean productivity of both the tilling and POP activity is less than the expected productivity implying that the both productivity is ok in comparison to what is expected of such gang within Abuja.

Conclusions

The research objective was to study the labour productivity of permanent and contract staff productivity of POP workers and tilers in Abuja with the view to advice properly the best staffing method for those crafts on site. The study revealed that the productivity of contract staffs is better than that of permanent staff for both pop workers and tilers. The study therefore recommends contract staff for such craft work for better productivity. This must be done without undermining the workers wellbeing and profit also.

References

Abdul-Rashid, K. & Hassan, S.F., 2005. Capability of a country's construction industry to combat poverty: A case study on the OIC member countries, *Proceedings of the 4th MICRA Conference* 2005, 4-5.

Abubakar, M., Ibrahim, Y.M., Kado, D. & Bala, K., (2014). Contractors' Perception of the Factors Affecting Building Information Modelling (BIM) Adoption in the Nigerian Construction Industry. *Computing in Civil and Building Engineering (2014)*, 167-178.

Agbo A.E. and Ayegba C. (2014) Critical Factors Influencing Construction Labour Productivity in Carpentry and Steel Fixing in North Central Nigeria. International Journal of Development and Sustainability. 3(8) 1675-1684.

Agbo, E. A., Izam, Y. D., and Ayegba, C. (2021). "Quantifying the Impact of Work Environment Factors on Variability of Labour Productivity in Wall Plastering" Journal of Construction in Developing Countries (JCDC) EARLY VIEW.

Attar, A. A., Gupta, A. K., & Desai, D. BD. B. (2012). "A study of various factors affecting labour productivity and methods to improve it", *Journal of Mechanical and Civil Engineering*. 2 (2),11–14.

Badmus, B. G., Oladiran, A. & Badmus A. T. (2020), "Modernisation or Modern Slavery: The Concept of Casual/Contract Labour and the Dilemma of Economic Growth in Nigeria", *ARC Journal of Addiction*, 4 (2),17-33.

Campbell, I. & Brosnan, S. (2004). Casual work and Casualization: Labour and Industry. Centre for workplace culture changes, Sydney.

Fellows, R. F., & Liu, A. M. (2021). *Research methods for construction*. John Wiley & Sons.

Gopal, T. S. R., & Murali, K. (2015). A critical review on factors influencing labour productivity in construction. IOSR Journal of Mechanical and Civil Engineering, 12(5), 47-51.

Indeed, Editorial Team, (2021). Permanent Employment: Definition, Advantages and Differences from Other Employment Types. Indeed Carrier Guide. Feb, 2021. Retrieved from: https://www.indeed.com/career-advice/finding-a-job/permanent-employment.

Isaac A. O, Kevin C. O, & Jovita N. N. (2015) "A Comparative Evaluation of Labour Productivity of Wall Plastering Activity Using Work study" *PM World Journal* 4 (5), 2 – 3.

Jakas, A. M., & Bita, C. G. (2012). Factors Affecting Construction Labour in Kuwait. Journal of Construction Engineering and Management. 138(7), 811-820.

Jarosław M., Edyta P. & Michał J. (2019) "Formula for Determining the Construction Workers Productivity Including Environmental Factors" *Building Journals*, 9 (1), 240

Liu, M. & Ballard, G., (2008). "Improving labour productivity through production control", *Proceedings of the 6th Annual Conference of International Group for Lean Construction, Manchester*, United Kingdom. 657-666.

Mahesh K.S, & Kassim Reshma (2017), "Factors Affecting Labour Productivity in Construction Industries", *Imperial Journal of Interdisciplinary Research (IJIR)*, ISSN: 2454-1362, 3 (6),130-133

Owolabi, O.S.B. & Olatunji, A.S., 2014. The Roles of Construction Professionals in the Nigeria's Construction Industry. *IOSR Journal of Humanities and Social Science (IOSR-JHSS)*, 19(11), 5.

Rabia Almamlook, Mohamed Bzizi, Maha Al-Kbisbeh, Tgarid Ali, & Ekbal Almajiri, (2020) Factors Affecting Labour Productivity in the Construction Industry, *American Journal of Environmental Science and Engineering*. 4 (2) 24-30.

Rao, B. P., & Sudhanva, N. (2017). Micro and macro-level analysis of labour productivity. International Journal of Civil Engineering and Technology, 8(8), 500–507.

Reshetnikova, I., Zotkina, N., & Gusarova, M. (2019). Selection of recruitment methods in construction organizations. In *MATEC Web of Conferences* (Vol. 265, p. 07009). EDP Sciences.

Salehi, M, Shirouyehzad, H. & Dabestani, R. (2013) 'Labour productivity measurement through classification and standardization of products', *International Journals of Productivity and Quality Management*, 11(1), 57–72.

Wilcox, S., String fellow, B., Harris, R., & Martin, B. (2000). "Management and Productivity." Transportation Research Board, Committee on Management and Productivity, Washington, DC.

An Investigation of the Satisfaction Level of Student Accommodation and Resilience of Students' Living Environment of Modibbo Adama University of Technology, Yola, Nigeria

Ekule, A.A.[1]; Abdul, C.I.[1,2]; Idachaba, M.K.[1] & Abdullahi, N.A.[1]

[1]*Department of Architectural Technology, School of Environmental Technology, Kogi State Polytechnic, Lokoja*
[2]*School of Architecture Programmes, Faculty of Built Environment and Surveying, Universiti Teknologi Malaysia, Johor, Malaysia.*
ekuleadejoh@yahoo.com; ileanwa@graduate.utm.my; kidachaba@yahoo.co.uk; arcnuhu@gmail.com
Correspondence email: *ekuleadejoh@yahoo.com*

Abstract

Many of the world's acute problems such as crime, poverty, pollution and destruction of the environment are linked to the unchecked growth of human species. The major problem identified as cause of dissatisfaction in the students' living environment is the occupancy ratio as compared with the population density. This research is aimed at determining the student's level of satisfaction with the physical condition of structures, facilities and utilities in the area under study. The objectives are to assess the implications of overcrowding on the physical condition of the sampled structures and its effects on satisfaction level of students with available facilities and identify its social and psychological effects on occupants. Systematic evaluation of selected occupied hostels in Modibbo Adama University of Technology, Yola, Adamawa State, North-east of Nigeria was carried out and achieved by using a quantitative research method to explore users' opinion on preferred spatial needs, level of satisfaction, space organization and preferred numbers of users to share facilities. Data were obtained through primary and secondary sources. The frame work of the study was expanded to address physical and social variables. Stratified sampling technique to get male and female participants and systematic sampling to get participant from selected rooms at an interval calculated from 15% of 1008 male and 30% of 448 female population in the hostels. Physical congestion, overburdened physical, social and public facilities, utilities and services affect the structures. It is recommended that adequate accommodation for students be provided, strict adherence to standard in the number of occupants per dwelling unit be adhered to and elimination of squatters and illegal occupants be adopted.

Keywords: *Facilities, Living environment, Overcrowding, Satisfaction, Students*.

Introduction

The word "density" refers to the physical conditions created by varying quantities of space and populations of people; when density rises, a person may encounter more people or fewer spaces accessible for their usage (Baum and Koman, 1976).With an increase in students due to an increase in interest in tertiary institutions of learning over time, student housing has become a major issue of concern. The burden on the academic and residential facilities of Nigeria's public institutions has increased as a result of the desire of many students to continue their education there. The study is aimed to determine the student's level of satisfaction with the physical condition of structures, facilities and utilities in the study area, the effects of overcrowding on the dissatisfaction of students with these factors through obtaining users' level of satisfaction with hostel space and facilities and the most preferred number of users to share space and facilities. It is essential for schools to prioritize student housing while boosting the school's reputation among its peers because student housing is one of the amenities that students examine before choosing the school they wish to attend, among other factors (Toyin Sawyerr and Yusof, 2013).

It is crucial for student housing to offer the basic infrastructure facilities needed by the student, such as toilets, water supply, electricity, reading rooms, canteens, butteries, kitchens or kitchenettes, and recreation areas. The provision of these facilities in good working order is typically not always readily available (Adedeji, 2016). The university administration must take into account how well the students are treated because this has an impact on their ability to do well academically, especially when they enjoy their studies and have a comfortable lifestyle (Mansor *et al.*, 2020). In order to help housing administrators and facility managers at higher education institutions enhance their services and provide better housing facilities in the near future, we intend to analyse the residential satisfaction of students (Najib, 2011).

Housing satisfaction is influenced by a variety of individual elements, including life stages, social and cultural background, financial condition, and aspirations, as well as the architectural features of a structure or residence. By contrasting their preferences with their actual living circumstances, people gauge their level of housing satisfaction (Thomsen and Eikemo, 2010). Student affairs administrators have a special opportunity to enhance and support university students' educational experiences through student living facilities (Navarez, 2017).

The availability of top-notch student housing facilities is anticipated to serve as an efficient recruitment tool for local and foreign students to Malaysian universities, and additional efforts should be directed toward raising the index's score on the student residential satisfaction scale ('Ulyani Mohd Najib *et al.*, 2011). The basis for making decisions about improvements to the current housing stock and the design and development of future housing is the evaluation of student housing facilities. Additionally, the possibility of conducting a performance evaluation of housing increases the accountability of housing managers, designers, and policy makers (Amole, 2009).

Research Methods

The research was carried out using a case study research design method. The information needed for the effective execution of this research work were derived from the assessment of sampled university student hostels of the study area, direct physical observations and the administration of questionnaire in the studied student housing to get response from personal opinion of the residents in the student halls of residence.

Stratified random sampling was also used to get a sample from two different groups with respect to gender difference (male and female) and Systematic sampling technique as explained by Jen (2007) to get samples of residents from each previously sampled hall of residence in the study area. 15% of the total population of each hostel was sampled which is 5% higher than the minimum of 10% population as explained by Jen (2007) for more accuracy. The sampled buildings were: Kabir Umar Male Hostel and Chukwu Female Hostel.

Previous Studies

According to the study on assessment of the state of the facilities in the student residence halls at Obafemi Awolowo University by Adedeji (2016), more than the average number of facilities at the University are in deteriorating condition. The findings revealed that 54% strongly agreed that the water closet is bad, 54.4% and 38.9% strongly agreed that the bathroom and water closet were both bad, 39.3% strongly agreed that the window/door was bad, 22.6% strongly agreed that the electric appliance was bad, and 64.6%. The study concluded that student's lives will be endangered if the facilities are not fixed in their proper condition to serve the students. In order to ascertain the degree of students' satisfaction with the conditions of the facilities and the dormitories in Federal Universities in North Central Nigeria, satisfaction evaluations were carried out by Philip *et al.*, (2018). According to the findings, 91.7% of the students were dissatisfied with their hostel accommodations, whereas 8.3% of the respondents were satisfied. The study came to the conclusion that the bad condition of the hostel facilities would rather make a hostel look like a shelter and would adversely influence the quality of education and the student's psychology toward differentiating between standard and ordinary facilities in a larger community.

In a study to determine the impact of space design on occupants' contentment with indoor environment in university dorms, Dong *et al.*, (2022) examined five types of spaces to determine the most satisfying space type, and discovered that single and double rooms with balconies offered more satisfaction. The area per capita increased along with the pleasure of the tenants, although the growth was only moderate after the value reached 13.5 m2. The study added a fresh perspective to the field of indoor environmental quality research by demonstrating the significance of space design on occupant happiness, which warrants further study.

In Bangladesh's public universities, Rahman *et al.*, (2020) conducted a study to determine the key service parameters that affect students' satisfaction. The study concluded that the number of hostels was insufficient to meet the demand of the students, leading to their dissatisfaction with various services provided by the hostel authority as well as the absence of other services surrounding their hostels, and found a negative correlation between housing facilities and students' satisfaction, indicating that students are not satisfied with the housing facilities provided by the public universities. Using structured questionnaires to gather the data, a case study was conducted to assess the post-occupancy state of university residences at Southeast University of China (Ning and Chen, 2016). The findings demonstrated that university housing has top-notch physical amenities. They did not, however, deliver satisfactory services or a supportive infrastructure. This shows that while "software" is still less capable than "hardware," it may generally suit students' needs. Additionally, it has been discovered that the socio-technical systems approach has the quality of being integrated into the social, governmental, and geographical settings.

In a study conducted at University Utara Malaysia, Mansor *et al.*, (2020) found that there were differences in the degree to which undergraduate students were satisfied with the university's given housing amenities, as measured by the Relative Satisfaction Index (RSI). While the students were satisfied with the table and chairs, wardrobe, living area, and electricity in the room, they were dissatisfied with the washing machine, internet connection, shower accessories, sink, and toilet cleanliness. According to the study, a hostel's comfortable environment can have an impact on a student's academic performance.

According to a study by Osei - Poku *et al.*, (2020) to check students' satisfaction with their residences from the perspective of physical features, social amenities, and management factors, and considering purpose made halls and a converted halls, he revealed that individual Relative Satisfaction Index values indicate that students in the purpose-built hall are more satisfied with their accommodations while residents from the converted halls are more satisfied with their living arrangements,

Adegoke *et al.* (2021) in a study on the post occupancy evaluation of students hostels of Obafemi Awolowo University Ile-Ife using questionnaire and descriptive statistical tools found out that both sexes (male and female students) were generally content with social, indoor environmental quality (IEQ), and physical characteristics. However, while female students were also generally content with the supporting service, male students were generally unsatisfied. Additionally, IEQ and supportive services had an impact on both genders' levels of satisfaction.

In order to condense the data set and identify the connections between different aspects of students' contentment with their off-campus living, Muslim *et al.*, (2013) used the factor analysis approach. Results from a descriptive analysis indicate a level of satisfaction with each home environment level (house, neighborhood and city). This study reveals the large differences that exists between campus accommodation and off campus accommodation in universities.

Results And Discussion

This is in three main parts, the discussion on response to the questionnaire with questions relating to implications of the effects of overcrowding on students' satisfaction, the case studies and an application of the findings of the research finding. Equally the results are presented and discussed in accordance to the research questions to provide answers.

Presentation of Result

Research question 1: -What is the level of satisfaction with the hostel space and facilities?

The distribution in table 1 presents level of satisfaction with each facility spaces under the variables from the response of hostel users classified under the male and female starters consisting of 110 male respondent and 120 female respondents. The five Likert ordinal scale satisfaction was used; strongly satisfied, satisfied, fairly satisfied, unsatisfied and strongly satisfied.

a. Satisfaction level with study-bedroom: Majority of the male with percentage response of 40.91% was satisfied and female with percentage response of 33.33 % was fairly satisfied with the size of the study-bedroom. Majority of the male with percentage response of 40.91% was fairly satisfied and female with percentage response of 41.67 % was unsatisfied with the privacy in the study-bedroom. Majority of the male with percentage response of 47.27% was unsatisfied and female with percentage response of 37.5 % was strongly unsatisfied with the number of persons in the study-bedroom.

b. Satisfaction level with washroom facilities: Majority of the male with percentage response of 36.36% was fairly satisfied and female with percentage response of 37.5% were strongly unsatisfied with the number users sharing the bathroom. Majority of the male with percentage response of 31.82% was strongly unsatisfied and female with percentage response of 37.5% was unsatisfied with the size of the bathroom.

c. Satisfaction level with laundry facilities: Majority of the male with percentage response of 40.91% was satisfied and female with percentage response of 44.17% were unsatisfied with the size of the laundry space. Majority of the male with percentage response of 41.82% were satisfied and female with percentage response of 39.17% were satisfied with the cleanliness of the laundry space. Majority of the male with percentage response of 46.36% were fairly satisfied and female with percentage response of 42.5% were fairly satisfied with the number of persons sharing the laundry space.

Table 1: Students satisfaction with hostel facilities

S/N	VARIABLES		Frequency of Response		% of Response		Remark	
			M	F	M	F	M	F
1	**Satisfaction Level with Study Bedroom**							
	Size of the Study Bedroom	SS	20	20	18.18	16.67	Satisfied	Fairly Satisfied
		S	45	25	40.91	20.83		
		FS	25	40	22.73	33.33		
		US	15	30	13.64	25.00		
		SUN	5	5	4.55	4.17		
		Total	110	120	100.00	100.00		
	Privacy in Study Bedroom	SS	20	15	18.18	12.50	Fairly satisfied	Unsatisfied
		S	15	10	13.64	8.33		
		FS	45	25	40.91	20.83		
		US	15	50	13.64	41.67		
		SUN	15	20	13.64	16.67		
		Total	110	120	100.00	100.00		
	Number of Persons in Study bedroom	SS	18	15	16.36	12.50	Unsatisfied	Strongly Unsatisfied
		S	10	15	9.09	12.50		
		FS	25	20	22.73	16.67		
		US	52	25	47.27	20.83		
		SUN	5	45	4.55	37.50		
		Total	110	120	100.00	100.00		
2	**Satisfaction with Washroom Facilities**							
	Number Sharing the Bathroom	SS	15	15	13.64	12.50	Fairly Satisfied	Strongly Unsatisfied
		S	30	15	27.27	12.50		
		FS	40	20	36.36	16.67		
		US	10	25	9.09	20.83		
		SUN	15	45	13.64	37.50		
		Total	110	120	100.00	100.00		
	Size of Bathroom	SS	15	0	13.64	0.00	Strongly Unsatisfied	Unsatisfied
		S	15	15	13.64	12.50		
		FS	20	23	18.18	19.17		
		US	25	45	22.73	37.50		
		SUN	35	37	31.82	30.83		
		Total	110	120	100.00	100.00		

Research question 2: What is the most preferred number of users to share space and facilities?

Majority of the male with percentage response of 67.27% prefer 3-4 students per each hostel room and majority of female with percentage response of 52.50 % suggested that a room in the hostel should contain 2 students maximum. None of the respondents indicated more than 7 students per hostel room.

Table 2: Preferred Number of Users per room.

Number of students in room hostel	**Frequency**		**Percent**		**Cumulative Percent**	
	M	**F**	**M**	**F**	**M**	**F**
2 students per room	34	63	30.9	52.5	30.91	52.5
3-4 students per room	74	52	67.3	43.3	98.18	95.83
5-6 students per room	2	5	1.82	4.17	100.00	100.00
7-8 students per room	0	0	0	0	100.00	100.00
> 8 students per room	0	0	0	0	100.00	100.00
Total	110	120	100	100		

Research question 3: Does overcrowding have any negative effect on the physical condition of the structures in the study area that contributed to dissatisfaction?

From the respondent's responses on the status of the hostels and what was seen physically during the field work, it was clear that the hostels were not in good condition as at the time of visit. Majority of the male respondents with the highest frequency of 50% described the hostels condition as unsatisfactory while majority of the female respondents with the frequency of 52.5% described it as strongly unsatisfactory. All the categories of the five Likert ordinal scale used accepted that the physical nature of structures and facilities are affected by overcrowding.

Table 3: The Status of the Hostel

Status of the hostel	**Frequency**		**Percent (%)**		**Cumulative Percent (%)**	
	M	**F**	**M**	**F**	**M**	**F**
Strongly Satisfied	2	0	1.82	0.00	1.82	0.00
Satisfied	7	3	6.36	2.50	8.18	2.50
Fairly satisfied	10	5	9.09	4.17	17.27	6.67
Unsatisfied	55	49	50.00	40.83	67.27	47.50
Strongly unsatisfied	36	63	32.73	52.50	100.00	100.00
Total	110	120	100.00	100.00		

Conclusion

Providing adequate space for education is not simply a matter of ensuring certain number of square metres of hostel accommodation for students. The study concludes on the followings;

A. Number of students that occupies a space in the hostel affects the academic performance of the students. Several vices are found on the campus and when a negative character is paired with too many students in a space, this causes emotional and psychological disturbances to the other roommates.

B. Fewer number of students per room enhances the academic performance of students. The more conducive an environment is, the better it is for the students to perform well academically.

C. Periodic checks are not being conducted to checkmate the number of students in hostels compared to the spaces provided for student's accommodation. Most universities are allowed to admit students beyond the university carrying capacity and this in turn affects the accommodation problems faced by the institution and students in particular.

D. Accommodation problems are not particular to Modibbo Adamawa University alone. Most universities in Africa and some Asian countries encounter the same challenges as reviewed from the study.

E. Off campus accommodation presently selling and expanding around university campuses are as a result of some comfort the students find there that are not available on campus accommodations which mostly are space related as fewer or single students live in a room on off campus accommodation for adequate convenience and comfort.

Recommendations

1. The present practice of admitting students before the issue of accommodation is considered should be stopped and a new system of attaching available accommodation to the admission process should be practiced so that only the students who can be accommodated will be admitted.

2. Public private partnership should be embraced to allow developers to build hostels on campuses and manage them for agreed period of time before they are transferred to the school management.

3. Minimizing the level of room occupancy by the establishment of maintenance and monitoring unit saddled with the responsibility of controlling the number of students per dwelling unit and periodical renovation of the hostels.

4. Adherence to standard in the number of people per dwelling unit and elimination of squatters/illegal occupants in the students' hostels.

5. There should be provision of adequate social amenities on campuses especially close to hostels to help the students in the relief of academic stress which in turn refreshes the students and also enhances their academic performances.

References

'Ulyani Mohd Najib, N., Aini Yusof, N. and Zainul Abidin, N. (2011) 'Student residential satisfaction in research universities', *Journal of Facilities Management*, 9(3), pp. 200–212.

Adedeji, I.- (2016) 'Causes and Effect of Deterioration in Students' Hall of Resident in Nigeria Tertiary Institution', *IOSR Journal of Humanities and Social Science*, 21(08), pp. 65–73.

Adegoke, A. S., Ajayi, C. A., Oladokun, T. T. and Ayodele, T. O. (2021) 'A post-occupancy evaluation of students' halls of residence in Obafemi Awolowo University, Ile-Ife, Nigeria', *Property Management*, 39(2), pp. 163–179.

Ainon, R. and Rosmaizura, M. Z. (2018) 'The impact of facilities on student choice', *Sci.Int.(Lahore)*, 30(2), pp. 299–311.

Ajayi, M. (2015) 'Students' Satisfaction With Hostel Facilities in Federal University of', *European Scientific Journal ESJ*, 11(34), pp. 402–415.

Amole, D. (2009) 'Residential satisfaction in students' housing', *Journal of Environmental Psychology*, 29(1), pp. 76–85.

Baum, A. and Koman, S. (1976) 'Differential response to anticipated crowding: Psychological effects of social and spatial density', *Journal of Personality and Social Psychology*, 34(3), pp. 526–536.

Dong, Z., Zhao, K., Ren, M., Ge, J. and Chan, I. Y. S. (2022) 'The impact of space design on occupants' satisfaction with indoor environment in university dormitories', *Building and Environment*. Elsevier Ltd, 218(April), p. 109143.

Mansor, R., Zaini, B. J., Sarkawi, M. N. and Phay, L. E. (2020) 'Relative Satisfaction Index on Students ' Satisfaction towards Hostel Facilities', *Test Engineering and Management*, 2(10757), pp. 10757–10765.

Muslim, M. H., Karim, H. A., Abdullah, I. C. and Ahmad, P. (2013) 'Students' Perception of Residential Satisfaction in the Level of Off-Campus Environment', *Procedia - Social and Behavioral Sciences*. Elsevier B.V., 105, pp. 684–696.

Najib (2011) 'Measuring Satisfaction with Student Housing Facilities', *American Journal of Engineering and Applied Sciences*, 4(1), pp. 52–60.

Navarez, J. C. (2017) 'Student Residential Satisfaction in an On-Campus Housing Facility Presented at the DLSU Research Congress 2017', *De La Salle University*, 1(2008), pp. 1–11.

Ning, Y. and Chen, J. (2016) 'Improving residential satisfaction of university dormitories through post-occupancy evaluation in China: A socio-technical system approach', *Sustainability (Switzerland)*, 8(10).

Osei - Poku, G., Braimah, A. and Clegg, R. (2020) 'Comparative assessment of user-satisfaction with on-campus residential accommodation at Takoradi Technical University, Ghana', *Journal of Building Performance*, 11(1), pp. 1–12.

Philip, A., Ileanwa, A. C. and El-Hussain, A. M. (2018) 'Post-Occupancy Evaluation of Students Hostel Facilities in Federal Universities in North Central, Nigeria', *Architecture Research*, 8(4), pp. 123–128.

Rahman, S. M. M., Mia, M. S., Ahmed, F., Thongrak, S. and Kiatpathomchai, S. (2020) 'Assessing students' satisfaction in Public Universities in Bangladesh: An empirical study', *Journal of Asian Finance, Economics and Business*, 7(8), pp. 323–332.

Simpeh, F. and Adisa, S. (2021) 'Evaluation of on-campus student housing facilities security and safety performance', *Facilities*, 39(7–8), pp. 470–487.

Simpeh, F. and Shakantu, W. (2020) 'An on-campus university student accommodation model', *Journal of Facilities Management*, 18(3), pp. 213–229.

Thomsen, J. and Eikemo, T. A. (2010) 'Aspects of student housing satisfaction: A quantitative study', *Journal of Housing and the Built Environment*, 25(3), pp. 273–293.

Toyin Sawyerr, P. and Yusof, N. A. (2013) 'Student satisfaction with hostel facilities in Nigerian polytechnics', *Journal of Facilities Management*, 11(4), pp. 306–322.

Prediction of Water Loss in Hydraulic Distribution System in Minna, Nigeria Using Artificial Neural Network

Yaba, T.[1,2], **Jimoh, O.D.**[1a], **Adesiji, A. R.**[1b]
[1]Civil Engineering Department, Federal University of Technology, Minna, Nigeria
[2] Niger State Water and Sewage Corporation, Minna, Niger State
[1.2]tanimuyaba@gmail.com; [1a]odjimoh@gmail.com; [1b]ade.richard@futminna.edu.ng
Corresponding Author: tanimuyaba@gmail.com

Abstract

Water supply network are prone to leakages resulting to a loss of large volume of water. Hence it is required to implement a leak detection/prediction technique through water simulation and machine learning. The main objective of this study is to model water loss in the distribution network of Shiroro District Metered Area. This is important because leak is a measure of efficiency of water distribution network. The hydraulic machine, EPANET was used for the hydraulic modelling of the networks. Emitters were used to simulate leakages at thirty-seven nodes in water distribution system. Physical measurement was carried out also at thirty-seven nodes in the network using measuring can, hose, GPS, meter, stop clock. Nash-Sutcliffe simulation efficiency (ENS) indicates how well the plot of observed versus simulated value fits the 1:1 line. The value of efficiency of 1 (when E = 1) means there is a perfect match of modelled discharge relative to the observed data. The observed and model data were loaded into NSE model using coefficient of 0.1, 0.15 0.2 and 0.3. The performance of the model has suggested that using the emitter coefficient of 0.2 can model the study area. Having established this, the values of the model could be used to predict leakages in the DMA using Artificial neural Network, ANN. This study was based on Multi-Layer Perception which was trained and tested using DMA flow data. The objective was to develop an ANN-based model using flow data generated in the selected DMA in Minna, Niger State, Nigeria. The input variables are elevation, base demand, demand and pressure of the network. The data was trained tested and validated in neural network. The study has shown 17.15% of loss from the nodes in the network. The sum of square errors 13.4% and 5.1% respectively for training and testing of the variables in the machine learning. R square is 97%. The model developed can be used in any district metered area of a distribution network to estimate or predict loss. The developed model is expected to help set the direction of improvement of the analysis of water distribution system and optimal operation of water supply in the studied DMA and other DMAs.

Keywords: Water Distribution System, EPANET, Emitter Coefficient, Artificial Neural Network

Introduction

Water distribution systems are primary means of safe drinking water supply to the system. Water produced and delivered to the distribution system is intended for the customers or users. However, a significant amount of water is lost in the system before it gets to its intended users as leak which is termed a physical component of Non-Revenue Water. The occurrence of leaks depends on the factors like materials, composition, age, pressure and joining. Due to complexity of the distribution system, it may be difficult for the utility personnel to identify and fix all the leaks. Hence the need for the development of methodology to identify the leaks using model by integrating observation data

Current statistical surveys indicated that NRW in developing countries is around 45 to 50% that is half of the total system input volume. A high level of apparent losses reduces the principal revenue stream to the utility. Zabidi *et al*. (2020) reported that losses in water distribution system in some urban areas in Nigeria is as high as 50%. High levels of water losses are indicative of poor governance and poor physical condition of the Water Distribution System, WDS, (Mamlook *et al*., 2003). The amount of water loss in water distribution systems varies widely from one system to another, from as low as 3–7 % to as high as 50 % of distribution input volume in the well-maintained systems of developed countries and less maintained system in developing countries respectively (Lambert, 2002).

Regular maintenance of infrastructure also helps to maintain water efficiency levels and is more cost-effective than rehabilitation (Makaya,2014). Many water distribution systems in developing countries are operated under intermittent conditions (WWAP, 2014). As a result, water supply efficiency in these countries is compromised.

Losses from leaks that are discovered and repaired should be measured to determine the rate of loss and the total volume lost during the life of the leak. Three methods are suggested (from Leak Detection Productivity ‘’) by Douglas (AWWA California Nevada section, 1992).

1. Use a container of known volume.
2. Use a hose and a meter.
3. Calculate losses using modified orifice and friction formula.

An effective leakage management strategy should take into account the pressure dynamics of a water distribution network. This is because pressure plays a pivotal role in enhancing the magnitude of water leakage. This is because there is a physical relationship between leakage flow rate and pressure. Thus, the pressure exerted by either gravity or by water pumps results in a corresponding change in leakage rate. The frequency of new pipe bursts is also a function of pressure such that the higher or lower the pressure, the higher or lower the leakage. Pressure level and pressure cycling strongly influence burst frequency. Some of the most important ways of managing pressure is by either using pressure reducing valves (manual or automatic) or by using variable speed pump controllers. Under normal circumstances a pressure reducing valve is used to maintain a fixed downstream pressure regardless of the upstream pressure dynamics. The leakage from water distribution systems has been shown to be directly proportional to the square root of the distribution system pressure as indicated by the relationship (Wallingford, 2003).

Evidence shows that the rate of increase of bursts is more than linearly proportional to pressure. Indeed, it has even been suggested that there could be a cubic relationship, i.e. burst frequency proportional to pressure cubed (Farley and Trow, 2003).

Most software such as EPANET, is a widely used water distribution network simulator developed by the Environmental Protection Agency (EPA), requires that sub-components for distribution storage and piping be inputted with the necessary information.

Nash-Sutcliffe simulation efficiency (ENS) indicates how well the plot of observed versus simulated value fits the 1:1 line. The Nash–Sutcliffe model efficiency coefficient is used in assessing the predictive power of hydrological models. Nash–Sutcliffe efficiency ranges from infinity to 1. The value of efficiency of 1 (when E = 1) means there is a perfect match of modeled discharge relative to the observed data. The value of efficiency equal to (when E = 0) shows that the predictions of model are as accurate as the mean of the observed data, whereas an efficiency below zero (E < 0) occurs when the observed mean is a better predictor than the model or, in other words, when the residual variance, is larger than the data variance (the denominator). Therefore, the closer the model efficiency is to 1, the more accurate the model is (Karthikeyan et al. 2013). And according to Dongquan et al. (2009), an E_{NS} greater than 0.5 indicates acceptable model performance for model simulation.

Artificial Neural Networks (ANN) comprise of a network of neurons and take the cue from their biological counterparts. ANNs have found wide application in modelling water resources management problems including leakage detection, water distribution network optimisation, water pipeline replacement and rehabilitation, water demand forecasting, and pressure monitoring. Hamideh *et al*. (2021) proposed a new method to locate a leakage in WDNs using feedforward artificial neural networks (ANNs).

Methodology

Water Distribution Network Simulation

The hydraulic machine, EPANET was used for the hydraulic modelling of the networks

Other software machines employed are for data collection to accomplish this assignment include: ArcGIS, AutoCAD and Google Earth Pro.

Shapefiles from digitized map of transmission and distribution mains, reservoirs, tanks and valves were loaded to AutoCAD all geo referenced. These shape files loaded into AutoCAD were converted to metafile and used as backdrop in EPANET. The simulated backdrops were saved as NET File or INP file in EPANET interface

The shapefiles were as well converted to KML and superimposed in google earth to obtain nodal elevation values. The shapefiles were equally loaded in AutoCAD and then converted to DXF file for terrain extractor to assign the nodal elevation values as check for nodal values. TCX converter utilized as well to verify correctness of key nodal point values which were viewed in excel sheet..

Comprehensive data analyses were carried out, Geo referenced network maps successfully loaded on to EPANET interface for modelling.

Model Calibration

Nash-Sutcliffe simulation efficiency (ENS) indicates how well the plot of observed versus simulated value fits the 1:1 line. The Nash–Sutcliffe model efficiency coefficient is used in assessing the predictive power of hydrological models, and it is defined as

$$E = 1 - \frac{\sum_{t=1}^{T}(Q_o^t - Q_m^t)^2}{\sum_{t=1}^{T}(Q_o^t - \bar{Q}_o)^2} \qquad (1)$$

Where;

Q_o = mean of observed discharges, and

Q_m = modeled discharge and

Qo^t = observed discharge at time t.

Nash–Sutcliffe efficiency ranges from infinity to 1. The value of efficiency of 1 (when E = 1) means there is a perfect match of modeled discharge relative to the observed data. The value of efficiency equal to (when E = 0) shows that the predictions of model are as accurate as the mean of the observed data, whereas an efficiency below zero (E < 0) occurs when the observed mean is a better predictor than the model or, in other words, when the residual variance (numerator in equation (1), is larger than the data variance (the denominator). Therefore, the closer the model efficiency is to 1, the more accurate the model is (Karthikeyan et al. 2013). And according to Dongquan et al. (2009), an E_{NS} greater than 0.5 indicates acceptable model performance for model simulation.

Neural network construction predicts the independent variable giving the available information of independent variables, Neural networks are made up of a series of layers with each layer comprising at least one neuron. While intermediate layers (hidden layers) perform the data processing functions of the network, the first and last layers input and output variables respectively. Within the hidden layers, weights to the neurons are adjusted by training the network in accordance with the stipulated learning rule (Zealand et al., 1999).

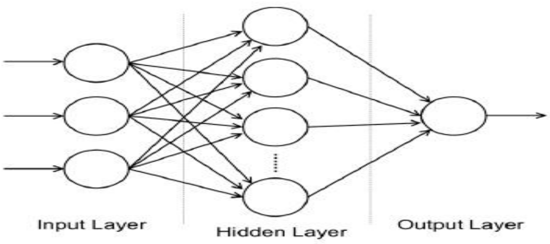


Figure1: Neural Network Diagram

3Model Calibration using NASH Sutcliffe Efficiency Coefficient and Artificial neural network

Emitters were used to simulate leakages at nodes. This is given by the equation

$$Q = a * P^{b} \qquad (2)$$

Where Q = leakage (Q_{leak}), a and b are discharge coefficient and emitter exponent respectively and P is the pressure at the node.

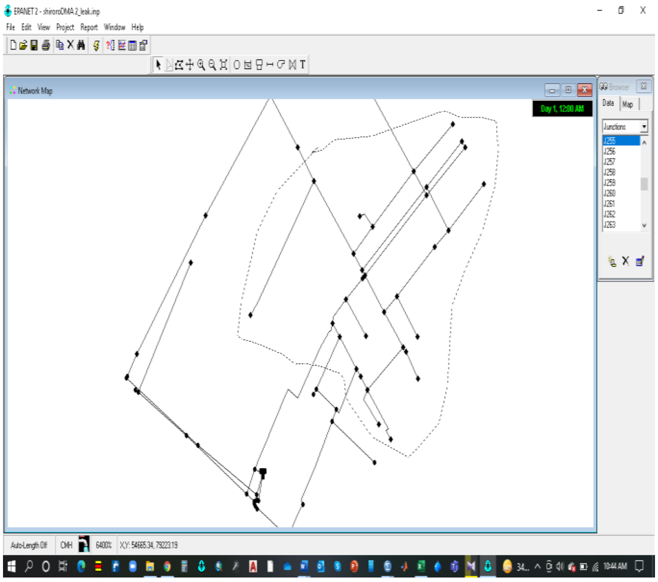


Figure 2: EPANET interface of Shiroro DMA showing the selected nodes for analysis

Result

Modelled and Observed Data Test in NS

Analyses at 8 to 11th hours

Using the leak coefficients of 0.1, 0.15, 0.2 and 0.3 in the emitter equation

$Q_{leak} = a * P^{N}$ at 8 and 9 hours, observed and modelled data loaded in the NASH provided the NASH Sutcliffe Efficiency Coefficients of -4.552, 0.092, 0.73, 0.187 and -3.777, 0.143, 0.68 and -0.07. NSE at 10 and 11 hours are -2.573, 0.286, 0.582, -0.288 and -0.689, 0.256, 0.516 and -0.826 These values deviated from the required standards of perfect or nearly perfect match except at 0.2 which gives a nearly perfect match

The performance of the model has suggested that using the emitter coefficient of 0.2 can model the study area. Table 1 shows the model performance in NSE

Table 1: Summary of the Model performance in NSE

	a			
Hour	0.1	0.15	0.2	0.3
8	-4.552	0.092	0.73	0.187
9	-3.777	0.143	0.68	-0.07
10	-2.573	0.286	0.582	-0.288
11	-0.689	0.256	0.516	-0.826

Summary of the of the modelled and measured leak is shown in Table 2

Table 2: Simulated and Observed Leaks at the site

	Base Demand (m^3/h)	Demand (m^3/h)	Pressure (m)	Simu_Q_{leak} (m^3/h)	Obs_Q_{leak} (m^3/h)
249	0.87	1.67	16.08	0.8	1
242	0.87	0.87	24.16	1	0.7
252	3.86	4.61	13.88	0.7	0.8
253	0.87	1.59	12.83	0.7	0.6
250	0.87	1.65	15.32	0.8	0.1
252	3.86	4.59	13.28	0.7	0.9
252	0.87	1.6	13.27	0.7	1
243	0.87	1.81	22.06	0.9	1
254	3.86	4.51	10.53	0.6	0.5
253	0.87	1.55	11.53	0.7	0.6
252	0	0.72	12.79	0.7	0.6
252	0	0.71	12.72	0.7	0.8
254	0.87	1.52	10.53	0.6	1.1
254	3.86	4.51	10.55	0.6	0.8
251	3.86	4.59	13.33	0.7	0.6
251	3.86	4.6	13.67	0.7	0.6
0	3.86	7.11	264.68	3.3	3
248	0.87	1.69	16.72	0.8	0.8
246	0.87	1.74	18.71	0.9	1

Having established this, the values of the model can now be used to predict leakages in the DMA using Artificial neural Network, ANN. The study has shown 17.1% of loss in the network.

Table 3: Summary of flow logging data

Elevation (m)	Base Demand (m^3/h	Demand (m^3/h)	Pressure (m)	Simu_Q_{leak} (m^3/h)
248	0.87	1.69	16.72	0.8
246	0.87	1.74	18.71	0.9
246	0.87	1.74	18.71	0.9
252	0.87	1.58	12.71	0.7
251	0.87	1.61	13.62	0.7
248	0.87	1.69	16.61	0.8
250	0.87	1.63	14.55	0.8
249	0.87	1.66	15.52	0.8
255	3.86	4.47	9.19	0.6
247	3.86	4.69	17.14	0.8
254	3.86	4.5	10.29	0.6
248	3.86	4.67	16.29	0.8

Table 4: Model Validation Result in ANN

Elevation (m)	Base demand (m^3/h)	Actual Demand (m^3/h)	Pressure (m)	Leak (m^3/h)	MLP_PredictedValue (m^3/h)
249	0.87	1.67	16.08	0.8	0.79
242	0.87	0.87	24.16	1	0.98
252	3.86	4.61	13.88	0.7	0.7
253	0.87	1.59	12.83	0.7	0.7
250	0.87	1.65	15.32	0.8	0.77
248	0.87	1.67	15.89		0.8
246	0.87	1.72	17.89		0.85
246	0.87	1.72	17.89		0.85
252	0.87	1.56	11.89		0.69
251	0.87	1.59	12.8		0.72

In this model calibration, sum of square errors for training and testing are 13.45% and 5.1% respectively.

The sum of square errors for samples trained and tested is depicted in Table 5 Table 6 indicate the model summary in percentages of the valid samples.

Table 5: Model Summary

Training sum of square error	Testing sum of square error
	0.051

Table 6: Case Processing Summary

Training samples	Testing samples	Validity	% trained	% tested	% valid	Samples excluded
83	28	111	74.8	25.2	100	37

The predicted and the real values of leaks are depicted in Figure 3

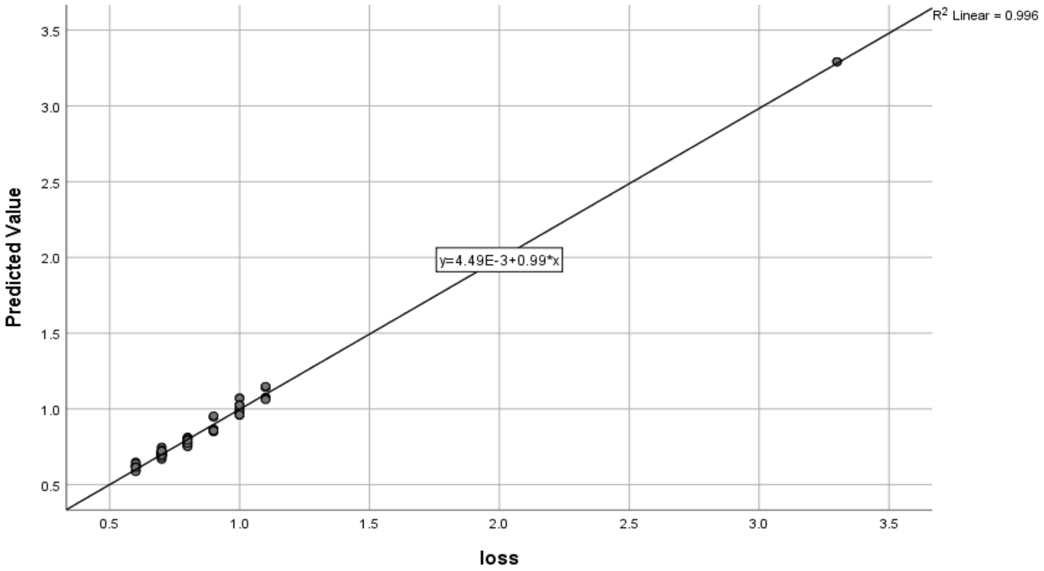


Figure 3: Real loss and predicted values of loss

The result showed that the model built can estimate the amount of leak, given elevation, base demand, demand, pressure and head as variables. This can be useful for water utilities in pipe inspection and maintenance. The value of R^2 indicates the model is doing well in terms of prediction

Conclusions

The main objective of this study is to model water loss in the distribution network of Shiroro District Metered Area. The model developed can be used in any district metered area of a distribution network to estimate the loss. R^2 linear .97% The errors are 13.4% and 5.1% respectively for training and testing of the variables in the machine learning. The input variables are elevation, base demand, demand and pressure of the network. The developed model is expected to help set the direction of improvement of the analysis of water distribution system and optimal operation of water supply in the studied DMA and other DMAs. This study has shown 17.1% of physical or real loss as NRW. This study has shown 17.1% of physical or real loss as NRW.

References

Dong-quan, Z. O., Hao-zheng, W. G., Ji-ning, C. N. & Hao-chang, W. G. (2009). Parameters uncertainty analysis of urban rainfall-runoff simulation, 20(1), 45-51.

Farley, M. (2003). Non-revenue water - International Best Practice for Assessment, Monitoring and Control Annual CWWA Water, Wastewater and Solid Waste Conference. Atlantis, Paradise Island, Bahamas.

Hamideh, F., Muhammadreza, J., Babak, A. & Jafar, Y. (2021). Ghazizadeh Leakage Detection in Water Distribution Networks Using Hybrid Feedforward Artificial Neural Networks

Karthikeyan, L., Kumar, D. N., Graillot, D. & Gaur, S. (2013). Prediction of ground water levels in the uplands of a tropical coastal riparian wetland using artificial neural networks. *Water resources management,* 27(3), 871-883.

Lambert A. O. (2002). A Water losses management and techniques. Water Science and Technology: Water Supply, 2(4), pp1–20,

Makaya, E. (2014). Water distribution systems losses. A guide for operation and maintenance. Cibew Publishing Company, Botswana, ISBN 978-99968-0-269-0.

Mamlook, R. and H. Al-Jayyous. (2003) Fuzzy sets analysis for leak detection in infrastructure systems: a proposed methodology. Cleaning Techniques and Environmental Policy, 6(1), pp 26-33.

Rossman, L. A. (2000). EPANET 2 User Manual. Water Supply and Water Resources Division National Risk Management Research Laboratory, Cincinnati, OH, EPA/600/R-00/057.

Segmasin Nig. Ltd. (1998) Assessment of unaccounted water in Bida and New Bussa, Nigeria. A report prepared in collaboration with Parkman Nig Ltd and submitted to Niger State

WWAP, (2014). United Nations World Water Assessment Programme, United Nations, New York.

Zabidi, H. A., Goh, H. W., Chang, C. K., Chan, N. W., & Zakaria, N. A. (2020). A review of roof and pond rainwater harvesting systems for water security: The design, performance and way forward. *Water*, *12*(11), 3163.

Zealand, C.M., Burn, D.H. and Simonovic, S.P. (1999). Short Term Streamflow Forecasting using Artificial Neural Networks. Journal of Hydrology, 214, 32-48.

Particulate Matter Exposure of Passengers at Bus Stops

Inufin, T.[1a], Shehu, M.[1b], Mahmud, M.[1c]
[1]Department of Civil Engineering, Federal University of Technology, Minna, Niger State, Nigeria
Corresponding author email: tinufin@gmail.com. +2348160901563

***Abstract*:**

The usual factors affecting the characteristics and composition of particulate matter (PM) pollution include industrial emissions and meteorological factors (temperature, humidity, wind speed, and rain volume) as well as bus-station-related factors such as fuel combustion in vehicles, wear of vehicle components, cigarette smoking, and vehicle flow. Several studies have proven that bus stops can accumulate high PM levels, thereby elevating passengers' exposure to PM while waiting at bus stations and leading to dire health outcomes such as cardiovascular disease (CVD), respiratory effects, and diabetes. The aim of this paper is to clarify PM pollution, including its levels, the factors affecting its distribution, and its health effects on passengers waiting at bus stops.

Keywords: *Particulate matter, Pollution, Passengers, Temperature, Humidity.*

Introduction

Transportation is the movement of humans, animals, goods and services from one location to another (Suh, 2009). It is hard to imagine living in a world without access to transport. Since time immemorial, people have come up with ways to move around rather than remain stagnant in one place (Fuzzi et al., 2015). Even when technology was in a stage of infancy and numerous modes of transportation were yet to be invented, there was always a way to take people, animals, and objects from one point to another (Tan et al., 2017). The role of a well-coordinated and smooth transport system is critical in the sound growth of a country (Nkaro, 2004).

The importance of transportation is showcased in how individuals, businesses, and governments rely on it to access resources (Betancourt *et al.,* 2017). Transport has helped to enhance life over the years and the current world would not be able to thrive without the ability to transfer things from one place to another.

However, despite these numerous benefits, the environmental impact of transport is significant because transport is a major user of energy, and burns most of the world's petroleum which results in the release of chemical and solid pollutants (Li *et al.*, 2017). This creates air pollution, including nitrous oxide and particulates, and is a significant contributor to global warming through carbon dioxide emission (Kingham *et al.*, 2011). Solid pollutants also known as particulate matter (PM) are usually emitted from automobiles while discharging their functions and it is suspended in the atmosphere as atmospheric aerosols (a mixture of PM and air) which are harmful to human health (Geiss *et al.*, 2010). In Nigeria, transportation has become a significant source of air pollution. The growing use of old, poorly maintained passenger cars and busses and the use of diesel fuel has dramatically worsened air quality (Oyetubo *et al.*, 2018).

Ukpata *et al.*, (2012) defined Pollution as the introduction of a substance that has harmful or poisonous effects on the environment. Air pollution is a mixture of thousands of components, all of which are harmful to human health but the most severe effects are attributed to particulate matter (Weidong *et al.*, 2019). The term exposure concentration refers to the concentration experienced over time spent in a particular microenvironment (Levy *et al.*, 2003).

According to Odekanle *et al.*, (2016), in Nigeria, people spend 1-1.5 hours per day travelling. Among all daily activities, episodes of high exposure to air pollution are experienced via commuting, especially in metropolitan areas where vehicle density is high. Concentrations of air pollutants are higher around busy roads and streets. It is more common in an urban commuting environment and mostly their levels peak during the morning rush hours (Hassan *et al.*, 2014). PM pollution has become an important concern worldwide due to its negative health effects on the ecosystem. PM is small enough to penetrate and deposit into many organisms of the body (Moore, 2012). When exposed to PM for a long time, people may acquire serious symptoms related to cardiovascular disease (CVD), arrhythmia and vascular dysfunction, lung cancer, skin irritation, diabetes and respiratory health challenges (Weidong *et al.,* 2019).

The growth in population and the increasing quest for a good standard of living through ownership of private vehicles have contributed to the problem of PM pollution (Oyetubo *et al.,* 2018). This has made the World Health Organization (WHO) revise its Ambient Air Quality Standard (AAQS) for PM, by classifying PM with its mean aerodynamic diameter. PM includes $PM_{10,}$ with an aerodynamic diameter 10µm or less; fine aerodynamic particulate is defined as $PM_{2.5}$of 2.5µm or less in diameter, and ultrafine particles $PM_{0.1}$ are categorized as extremely small, less than 0.1µm in diameter (Betancourt *et al.,* 2017).

Particulate matter (PM) is a component of the atmosphere that may be in liquid or solid form. It is suspended in the atmosphere as atmospheric aerosols; a complex mixture of carbon particles, hydrocarbons, and inorganics(Song *et al*., 2007). PM is unsafe at any exposure level, meaning there is no particle concentration threshold below which human health is not jeopardized (Tan *et al.,* 2017). Despite being relatively non-reactive, PM is highly variable in mass and composition in urban environments and tends to be divided into two principal groups: coarse particles and fine particles, and often contains chemically reactive substances on the particle surface (Ngoc *et al.,* 2018). The barrier between these two fractions of particles usually lies between 1 µm and 2.5µm. However, the limit between coarse and fine particles is sometimes fixed by convention at 2.5µm in aerodynamic diameter ($PM_{2.5}$) for measurement purposes (Moore, 2012). The smaller particles contain the secondarily formed aerosols (gas-to-particle conversion), combustion particles, and recondensed organic and metal vapours. The larger particles usually contain earth crust materials and fugitive dust from roads and industries. The fine fraction contains most of the acidity (hydrogen ion) and mutagenic activity of particulate matter, although in fog some coarse acid droplets are also present (Suh, 2009). Whereas most of the mass is usually in the fine mode (particles between 100µm and 2.5µm), the largest number of particles are found in very small sizes, less than 100µm (Levy *et al.,* 2003). As anticipated from the relationship of particle volume with mass, these so-called ultrafine particles often contribute only a few percentages to the mass, at the same time contributing to over 90% of the numbers (Tan *et al.,* 2017).

PM includes PM_{10}, with an aerodynamic diameter 10µm or less; fine aerodynamic particulate is defined as $PM_{2.5}$ of 2.5µm or less in diameter, and ultrafine particles ($PM_{0.1}$) are categorized as extremely small, less than 0.1µm in diameter(Levy *et al.,* 2003).

Table 66: Particulate Matter (PM) Classification.

Particulate Matter (PM)	Mean diameter (µm)	Description
PM_{10}	2.5-10 µm	Coarse
$PM_{2.5}$	<2.5 µm	Fine
$PM_{0.1}$	<0.1µm	Ultra-fine

The smaller the particle, the easier it is to travel along with sharp turns without colliding with the passage walls, and consequently, smaller particles reach deeper locations of the respiratory system, the deeper it settles, the more threatening it is for human health. PM_{10} (coarse PM) is known as inhalable particles that can penetrate the respiratory tract e.g., trachea, deep lungs, and bronchi. The coarse fraction of PM_{10} generally originates from construction and demolition operations, paved and unpaved roads, industrial processes, and agriculture as well as biomass burning.

Research Questions

The following research questions were raised to guide the study:

1. What is the relationship between the peak traffic occurrence time and the concentration of PM?
2. How can the degree of PM at bus stops exposure be accurately measured?
3. What is the short- and long-term effect of PM exposure on the health of passengers?

Methodology

Description of Study Area

Kpakungu is situated on scope 9'35'55'.00"N and longitude 6'32'00"E of Niger state. Kpakungu intersection is situated along the Minna-Bida corridor, a route that links many northern states to the important ports in Lagos, southwestern Nigeria. Federal University of Technology, Minna campuses, along with other schools sited in Kpakungu also are leading activities that attract high traffic to the corridor. There are also various businesses in the area due to the presence of many passengers plying the corridor.

Plate I: Aerial view of Kpakungu roundabout and its environs

Participants

350 questionnaires were distributed to the passengers to extract data concerning the health challenges they cope with because of frequent transit between both campuses using the buses, how it affects their work/academics and what improvements they think will be best to ameliorate the challenge of PM exposure that they have been subjected to at the bus stops. A total of 327 or 93.42% of questionnaires were returned. These were analysed using simple percentages and basic statistical tools to understand the trend of responses.

Instrumentation

Particulate matter (PM) concentrations were measured using SETRA Model 8506, an Aerosol Particle Mass Monitor from the SETRA systems 8000 series particle counter. It is a hand-held, battery-operated, and portable unit measuring six mass ranges of particulates: $PM_{0.3}$, $PM_{0.5}$ $PM_{1.0}$, $PM_{2.5}PM_5$, PM_{10}, with a range of $0.3\mu g/m^3$ –$10\mu g/m^3$. The sampling time is 4 min, for 12 hours on the first day, a flow rate of 2.83 l/min-measured in. To start taking a reading, it is switched on in the environment of interest and the measured concentration is read directly on the screen after the particle capturing. But for continuous sampling, the device was set to the appropriate time interval and the readings were stored.

At the location of interest, the monitor is placed at least 1 m above the ground level. When in operation, the air is drawn in through a small optical orifice, and a laser optical system counts and sizes the particles as they pass through. The readings from the device are stored in the memory banks which are then transferred to the computer via a memory stick and further analysis is carried out. The procedure will be repeated for 21 days at an interval of 4 hours from 8:00 a.m. to 6:00 p.m.

Data Collection and Analysis

Manual traffic count was carried out by observers situated at observation points at the side of the road. The traffic count collection was carried out at Kpakungu bus stop by counting the vehicles passing at the intersection and recorded on the tally sheet. The duration of the count was for 14 days from 7:00

a.m. to 7:00 p.m. The traffic count data was collected by the direct field manual methodology for numbering.

The results of a manual classified traffic count showed the total traffic volume and its composition by vehicle type in each direction. Thus, the count accurately reflected the traffic flow at Kpakungu road at that time of the year.

The methodology that is employed to investigate the relationship between traffic particulate matter exposures is regression analysis using MS Excel. Linear regression is a way to model the relationship between two variables. The variables considered for the linear regression is

The equation has the form $Y = a + bX$, where Y is the dependent variable (that is the variable that goes on the Y axis), X is the independent variable (that is, it is plotted on the X axis), b is the slope of the line and a is the y-intercept.

$$Y_i = f(X_i, ß) + e_i \quad (1)$$

Where;

Yi = dependent variable; f = function; Xi= Independent variable; ß = unknown parameters and

ei= errors terms

Results

A 1 day 10 hours data collection was carried out at four minutes intervals from 8:00 am to 6:00 pm. The summary of the data collected is presented in table 2. the data collected represents the traffic active section of FUT Minna Bosso campus-Gidan Kwano corridor.

Table 2: Summary of Particulate matter data collected.

	Time (4 minutes interval)	**Temp (ºC)**	**RH (%)**	**PM2.5 (µg/m³)**	**PM10 (µg/m³)**	**PM2.5/PM10**	**PCU**	
Average	8 a.m.	30.9	68.08	2.48	34.84	0.0711	32.9	20.4
Max	To	35.3	75	6.38	208.67	0.0306	71.0	44.0
Min	6 p.m.	28.6	55	0.99	7.16	0.1395	13.0	8.06

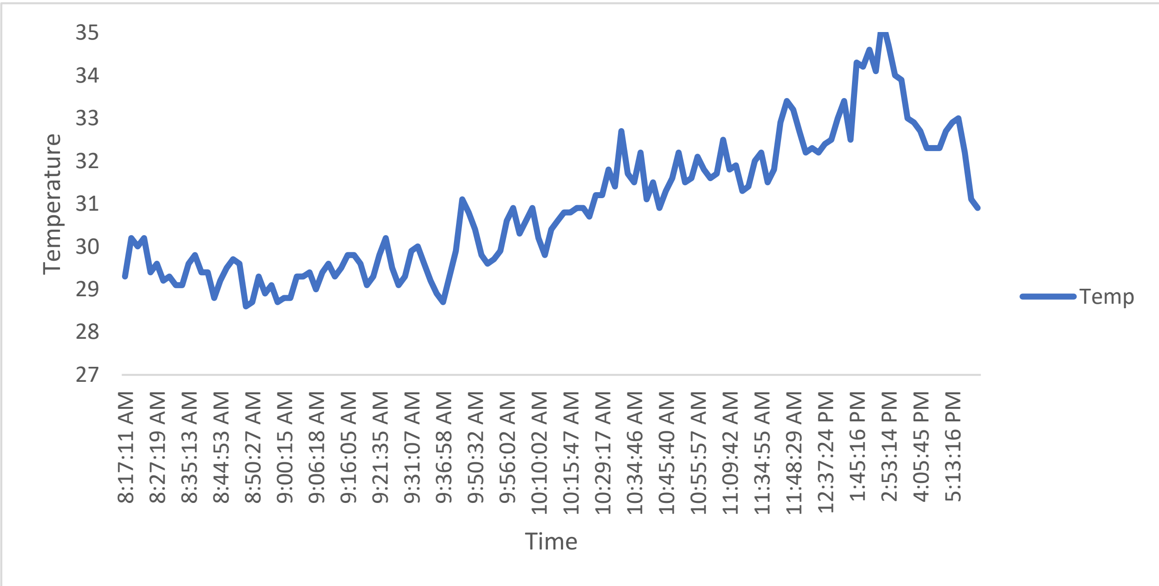


Figure 1: Range of temperature over the 10 hours recorded at a 4-minute interval

During the period of 10-hour data collection, the highest temperature recorded was at 35.3ºC at 2:52: 07 p.m. and a minimum of 28.6 ºC accruing at 8:49:20 AM.

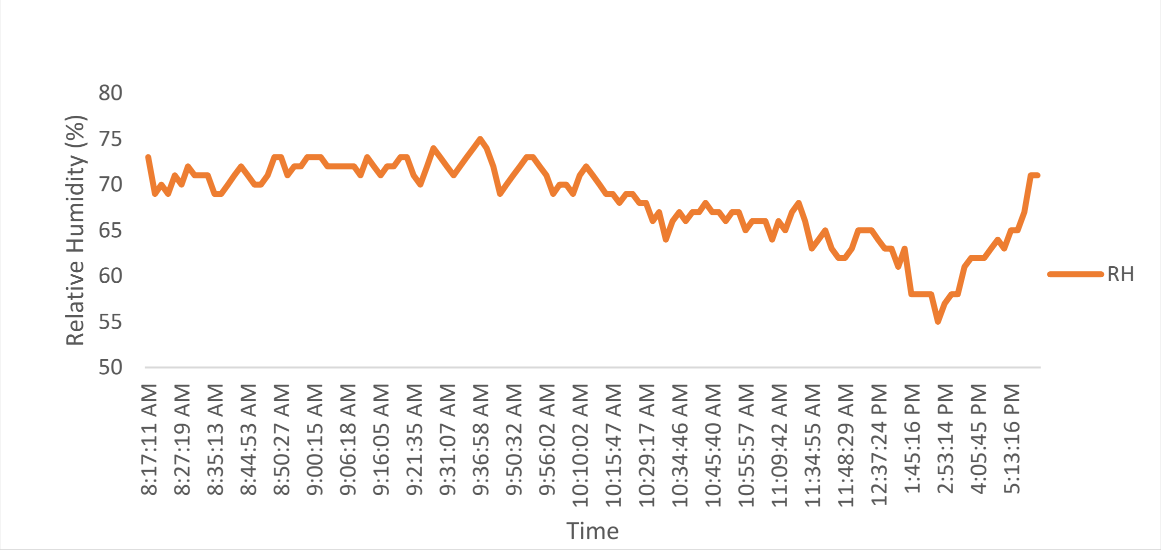


Figure 2: Relative humidity over the 10-hour period recorded at the 4-minutes interval.

During the period of 10-hour data collection, the highest relative humidity recorded was at 9:38:04 a.m. and a corresponding 75% while a 55% relative humidity occurred at 2:52:07 PM.

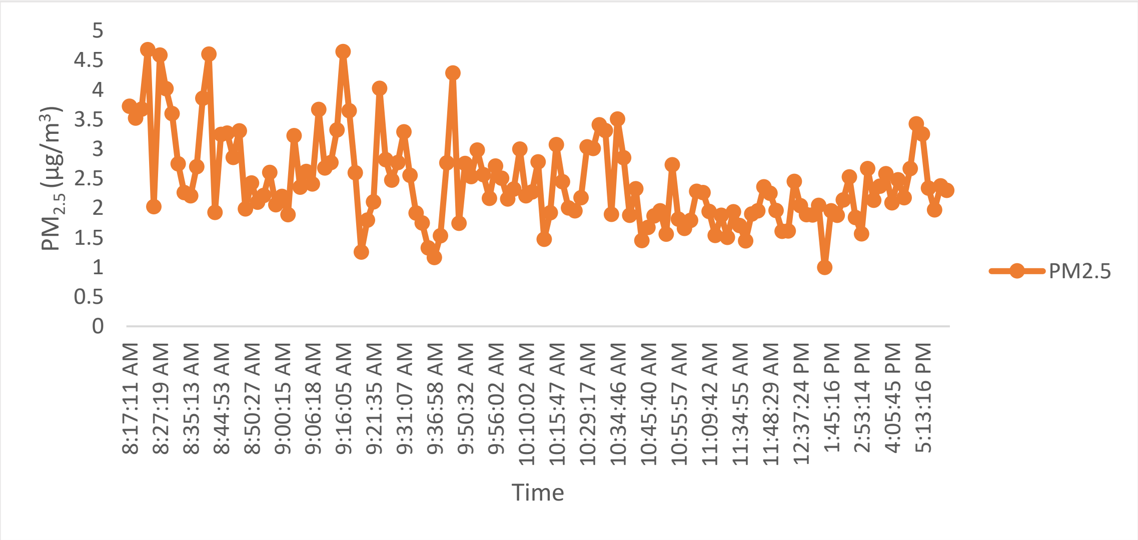


Figure 3: $PM_{2.5}$ for the 10-hour period recorded at a 4-minute interval.

During the period of 10-hour data collection, the highest occurrence of $PM_{2.5}$ recorded was at 6.38µg/m^3 and a minimum of 0.997 µg/m^3.

Figure 4 shows the trend of vehicles recorded During the period of 10-hour data collection the highest for the passenger cars (Motorcycles, Tricycles and Passenger cars) was 71 PCU at 8:42:41 AM and a minimum of 13 PCU at 10:58:14 AM and an average of 32.9 PCU.

The highest for the Trucks (Light trucks, buses, and heavy-duty trucks) was 44. PCU at 8:42:41AM and a minimum of 8.04 PCU at 12:57:49 PM and an average of 20.3 PCU.

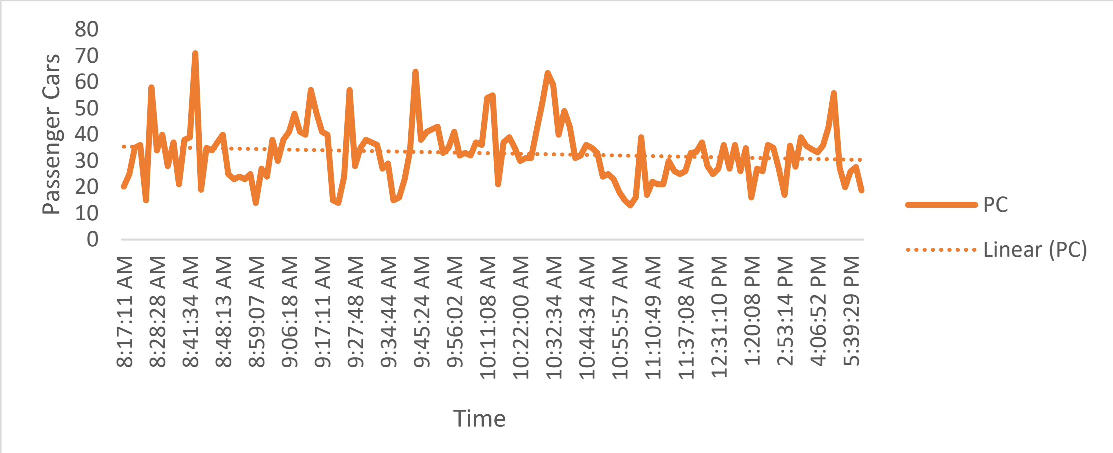


Figure 4: Passenger Car Traffic count for 10-hour study.

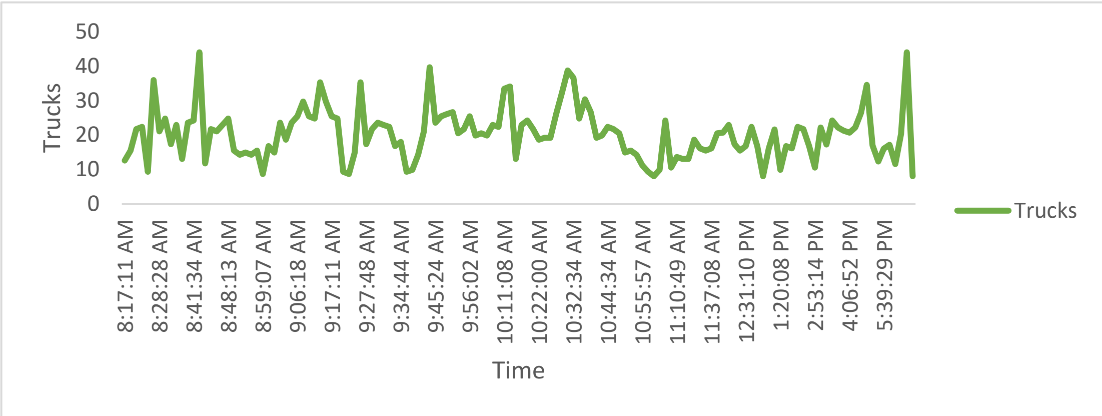


Figure 5: Trend of vehicles recorded during the period of 10-hour data collection.

Discussion of Results

The regression statistics table provides statistical measures of how well the model fits the data and it is presented in the table below:

Table 3: Regression statistics of 10 Hour study for $PM_{2.5}$

Regression Statistics	Values
Multiple R	0.094678
R Square	0.008964
Adjusted R Square	-0.01581
Standard Error	0.673422
Observations	83

The R-squared value of ~0.00896 indicates that the model accounts for about 0.896% of the dependent variable's variance. The adjusted R-squared value is used to compare regression models with differing numbers of independent variables. For example, when comparing a model with one independent variable to a model with two, the model with the higher adjusted R-squared is often preferred. Therefore, using the adjusted R-squared value with a value of -0.01581 it indicates that the model accounts for about 1.581% of the dependent variable's variance.

The standard error of the regression indicates the typical size of the residuals. This statistic

Shows how wrong the regression model is on average. Lower values signify that the distances between the data points and the fitted values are smaller.

Conveniently, this value uses the measurement units of the dependent variable. From the output, the standard distance between the predicted and observed values is 0.673422µg/m^3.

Table 4: Analysis of variance (ANOVA) for $PM_{2.5}$.

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	0.328153	0.164076	0.361802	0.697554
Residual	80	36.2798	0.453497		
Total	82	36.60795			

The most important statistic in the ANOVA table is Significance F. This is the p-value for the F-test of overall significance. This test determines whether the model with all its independent variables better explains the dependent variable's variability than a model with no independent variables. If this test result is not statistically significant, it suggests that the model is good. The p-value for the overall F-test is 0.697554.

Table 5: Coefficients Table for $PM_{2.5}$.

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	3.917814	2.438561	1.606609	0.11208	-0.93508	8.770706	-0.93508	8.770706
Temp	-0.04404	0.05672	-0.77637	0.439819	-0.15691	0.068841	-0.15691	0.068841
RH	-0.00248	0.01468	-0.169	0.866221	-0.03169	0.026733	-0.03169	0.026733

The coefficients table displays the parameter estimates for the independent variables in the model, along with the intercept value (constant). Temperature and Relative humidity are the two independent variables included in the model. The coefficient for temperature is approximately -0.04404. The negative sign indicates that as the temperature increases, $PM_{2.5}$ tends to decrease. For every one-unit increase in temperature, $PM_{2.5}$ decreases by an average of -0.04404µg/m^3.

The coefficient for Relative humidity is -0.00248. The negative sign indicates that as the Relative humidity increases, $PM_{2.5}$ tends to decrease. There is a negative association between these two variables. For every one-unit increase in relative humidity, $PM_{2.5}$ decreases by an average of -0.00248µg/m^3.

The p-values for the coefficients indicate whether the dependent variable is statistically significant. When the p-value is less than the significance level, the null hypothesis can be rejected because the coefficient equals zero. Zero indicates no relationship. When considering the two variables, MS Excel displays the p-values without using scientific notation because they are both not minuscule.

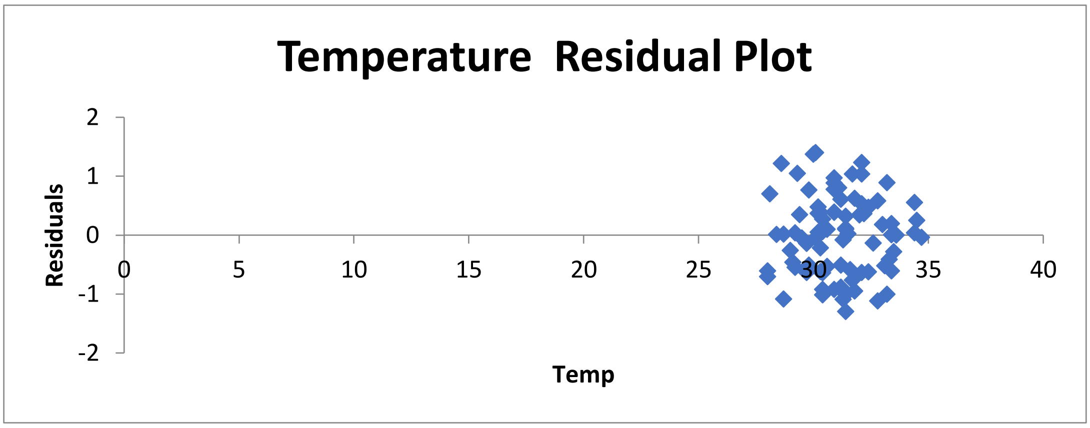


Figure 6: Residual plot for temperature $PM_{2.5}$

It is also crucial to examine the residual plots. The figure above shows the residual plot for temperature and the figure below shows the residual plot for relative humidity. Residuals are randomly scattered around zero which means the model fits the data.

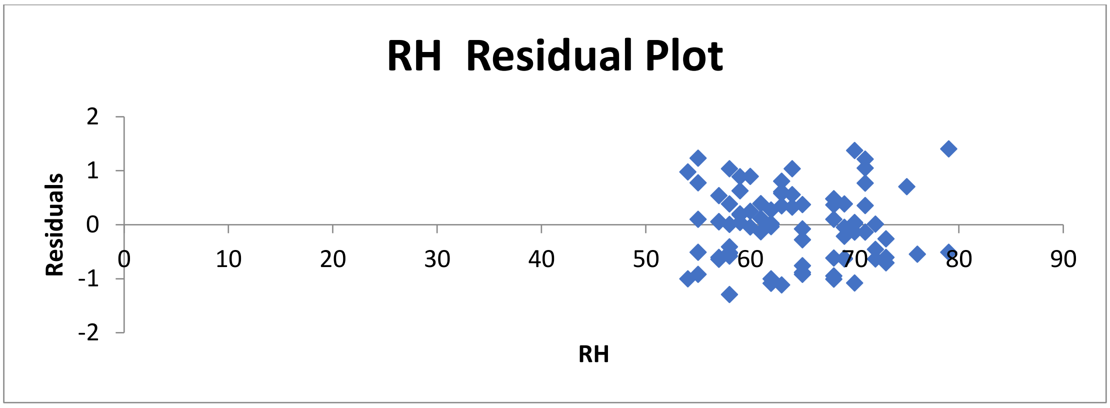


Figure 8: Residual Plot for Relative Humidity $PM_{2.5}$.

It can be deduced from the regression analysis carried out on the relationship between relative humidity and temperature that the changes in temperature and relative humidity do not affect the production of $PM_{2.5}$

Out of the total number of questionnaires returned, 90% of the respondent confirmed that they are usually been exposed to PM with short-term effect. This shows that almost all passengers and drivers plying the Kpakungu intersection road experiences short-term exposure. More so, 65% of the respondents choose 5-10 minutes average delay time before getting a means of transportation to their various destinations, this may be as a result of the recent government policy that banned the use of motorcycles as a means of transportation in the state. In addition, the bad state of the road due to its reconstruction also discourages the available means from using the Kpakungu road, hence this poses a threat to the commuters residing along the Kpakungu road. 53% of the respondent both drivers and commuters confirmed that due to the delay while moving through the intersection, they experienced headaches, chest pain and fatigue when exposed to the particulate matter within a short-term period. 59% of the respondent confirmed that, they use the intersection multiple times a day. This shows that most of them are likely susceptible to the long-term effects of exposure. The respondents revealed that long-term exposure causes some adverse effects such as cardiovascular diseases (CVD). However, this effect is not frequently noticeable as the effect in most commuters varies from short to long term.

Conclusion

This study identifies levels and factors affecting PM pollution at bus stations and calculates passenger exposure while waiting at Kpakungu bus stop as well as the health effects of such exposure. The relationship between the peak traffic occurrence, time and concentration of PM was carried. Commuters at the Kpakungu roundabout are exposed to an average of 2.3ug/m^3 $PM_{2.5}$ while they are exposed to an average of 38.5ug/m^3 of $PM_{10.}$ PM pollution at Kpakungu bus stop is primarily attributable to the combustion of fuels in vehicles, the wear of vehicle components (for example, tires and brakes), the suspension of road dust, cigarette smoking, and industrial emissions.

Recommendation

The following recommendations were made:

1. Reduction of the volume of automobiles plying the corridor especially at the Kpakungu roundabout by introducing big buses that carry more people with less PM production per capita.
2. Periodic data collection and analysis to ascertain the efficiency of the policy being implemented.

References

Adedayo, O., & Zubairu, S. (2016). Assessment of facilities in motor parks in Minna, Niger state, Nigeria, through post-occupancy evaluation. *Ethiopian Journal of Environmental Studies and Management*, *9*(5), 653. https://doi.org/10.4314/ejesm.v9i5.11

Aziz, K., Ali, Z., Nasir, Z. A., & Colbeck, I. (2015). Comparative study of particulate matter in the transport microenvironment (buses) of Pakistan and UK. *Journal of Animal and Plant Sciences*, *25*(3), 636–643.

Barmparesos, N., D. Assimakopoulos, V., Niki Assimakopoulos, M., & Tsairidi, E. (2016). Particulate matter levels and comfort conditions in the trains and platforms of the Athens underground metro. *AIMS Environmental Science*, *3*(2), 199–219. https://doi.org/10.3934/environsci.2016.2.199

Colvez, A., Castex, A., & Carriere, I. (2003). Réversibilité de l'incapacité chez les personnes âgées: Une étude du devenir à long terme en Haute-Normandie. *Revue d'Epidemiologie et de Sante Publique*, *51*(6), 565–573.

Dias Do Vale, I. (2014). *Comparison of pedestrians' particulate matter inhalation for different routes in urban centers Environmental Engineering Examination Comittee*. *June*. https://fenix.tecnico.ulisboa.pt/downloadFile/281870113701912/INES DO VALE dissertacao de mestrado.pdf

Hassan, A. B., Mohammed, A., Nasir, A., Okegbile, O. J., & Otoba, J. O. (2014). *Effect of Automobile Exhaust Gases Pollution in Minna Metropolis of Niger State*. *3*(3), 1–5.

Kasuga, H. (2014). Health effects of air pollution. *How to Conquer Air Pollution: A Japanese Experience*, *January*, 95–113. https://doi.org/10.2105/ajph.48.7.913

Moreland, L. (2004). Design Standards : Design Standards : *Public Administration*, *February*.

Ngoc, L. T. N., Kim, M., Bui, V. K. H., Park, D., & Lee, Y. C. (2018). Particulate matter exposure of passengers at bus stations: A review. *International Journal of Environmental Research and Public Health*, *15*(12). https://doi.org/10.3390/ijerph15122886

Nkaro, A. (2004). *Traffi c Data Collection and Analysis*. *99912-0-417–2*, 1–54.

O'Flaherty, C., Bonsall, P., & AD May. (2006). Transport Planning and Traffic Engineering Edited. In *Angewandte Chemie International Edition* (Vol. 6, Issue 11).

Odekanle, E. L., Fakinle, B. S., Akeredolu, F. A., Sonibare, J. A., & Adesanmi, A. J. (2016). Personal exposures to particulate matter in various modes of transport in Lagos city, Nigeria. *Cogent Environmental Science*, *2*(1), 1–10. https://doi.org/10.1080/23311843.2016.1260857

Oyetubo, A. O., Afolabi, O. J., & Ohida, M. E. (2018). Analysis of Road Traffic Safety in Minna Niger State, Nigeria. *Logistics & Sustainable Transport*, *9*(1), 23–38. https://doi.org/10.2478/jlst-2018-0003

Ukpata, J. O., & Etika, A. A. (2012). Traffic Congestion in Major Cities of Nigeria. *International Journal of Engineering and Technology*, *2*(8), 1433–1438.

Weidong, G., Wei, J., Xiaomei, G., & Mimi, Z. (2019). The analysis on air pollution characteristics at the bus stops in Jinan City. *IOP Conference Series: Earth and Environmental Science*, *295*(2). https://doi.org/10.1088/1755-1315/295/2/012002

Zuurbier, M., Hoek, G., Oldenwening, M., Lenters, V., Meliefste, K., van den Hazel, P., & Brunekreef, B. (2010). Commuters' exposure to particulate matter air pollution is affected by mode of transport, fuel type, and route. *Environmental Health Perspectives*, *118*(6), 783–789. https://doi.org/10.1289/ehp.0901622

Assessment of Quality Control of Tiles Production in West Africa Ceramics Company, Ajaokuta, Kogi State

Abdullahi, D.[1], Lawal S. S.[1] & Abdul, C. I.[2]
[1]Department of Mechanical Engineering, Federal University of Technology, Minna, Nigeria
[2]Department of Architectural Technology, Kogi State Polytechnic, Lokoja, Nigeria
sadiq.lawal@futminna.edu.ng, danladi4real@yahoo.com, ileanwa@graduate.utm.my
Correspondence email: danladi4real@yahoo.com

Abstract

Tiles industries has a mandate to comply with total quality management (TQM) process through Standard Organization of Nigeria (SON) for compliant with ISO-9001 certification process for continuous improvement on control, assuring and managing of quality process. The quality tiles require quality performance in industry and it is one of the major issues facing implementation of TQM in industry due to crucial process involved. The study assessed total quality management for producing tiles in WACC, Ajaokuta, Kogi State using ISO-9001:2015. Quality controls of the tiles were assured using P-chart, operation characteristics curve and mechanical resistance test. The performance level of TQM is assessed using correlation approach. Findings of study revealed that TQM in WACC using ISO-9001:2015 Standard indicated implementation level of 71% in year 2022. ISO-9001 based PDCA indicated 69.4% implementation of total quality management on continual project improvement. The compliance rating, P regression equation was: P= 4.75x+ 57.33 in which x is year after implementation of ISO 9001:2015. The six major tiles produced by WACC, Ajaokuta require maximum range of 0 to 3 defectives per daily batch production. The operating characteristic curve (OCC) showed that consumers are willing to none defective tiles of 40 x 80, 60 x 60, 120 x 60, 40 x 40, 25 x 40, 30 x 40 sq. cm. The study concludes that continuous improvement of quality standard implementation in WACC, Ajaokuta will boost the performance of tiles management and production.

Keywords: Production, Quality Control, Plant Extract, Wistar Rats, Phytochemical Analysis, histopathology

Introduction

The industrial process requires Total Quality Management (TQM) concept and if employed can make the development and improvement of quality products reliable and it will create added competitive advantage (Awoku, 2012). Most manufacturing companies have found themselves in a great competition for survival. This has driven companies to constantly desire to improve the quality of their products and reduce cost. Many of these companies are ready to make drastic changes according to the demands of the market in order to be ahead of their competitors. In today world market, there is a constant need for maintenance and continuous improvement of quality management (Zu *et al.*, 2010).

Meeting up with constant need for maintenance and continuous improvement of quality management requires TQM implementation practices. This will certainly improve the operational performance of manufacturing industry (Sila, 2007). Nigerian industry often fails to meet the required standards and client or customers' expectations. Thus, such products or services have continued to be plagued by quality issues, which contributes to long-term problems in the Nigerian industry (Ahaotu, 2018). According to (Maik, 2018), this scenario is worse in developing countries such as Nigeria where TQM implementations are not fully adopted. The non- adoption of TQM creates setback in Nigeria industries and this attribute to failing production processes and this affects the product quality (Sahran *et al.*, 2010).

There are several models of TQM which are developed with different principles for achieving quality process in industry. Christensen *et al*, (2014) identified the following models: Business excellence, Process improvement, ISO 9001, Six sigma, Juran, Demings, Ishikawa, Crosby and Feigenbaum Models.

Nigeria industries has a mandate to comply with TQM process through Standard Organisation of Nigeria (SON) for compliant with ISO-9001 certification process (SON, 2015). This is one of best TQM model known to adopted by the most industries in the world in quality process through International

Organization for Standardization (ISO). ISO-9001 is procedure for continuous improvement on control, assuring and managing of quality process by ISO. ISO 9001 is defined as international standard that specifies requirements for a quality management system (QMS), (ISO 9001, 2015). However, ISO is a standard procedure for assessing TQM processes. TQM is an extension of the quality assurance process beyond the production process that include application of proactive measures that guarantees quality of all the activities of the organisation and her outputs.

The present study tends to assess the implementation of TQM using ISO 9001:2015 in tiles production in which West Africa Ceramics Company Ajaokuta, Kogi State is adopted as case study.

Materials and Methods

Materials

The material in this research includes an evaluation checklist and test/measuring instruments and equipment. An evaluation checklist is developed using the requirements stated in ISO 9001:2015 for assessing total quality management (TQM) during production of tiles in WACC, Ajaokuta, Kogi State. The instrument used for different testing includes the following:

i. Weighing balancing machine
ii. Universal strength testing machine
iii. Pendulum Testing machine
iv. Vickers hardness testing machine

Methods

The technique for assessing Total Quality Management in WACC, Ajaokuta, Kogi State is in ISO-9001:2015 QMS standard.

The ISO-9001:2015 QMS standard requires the following 10 clauses:

i. Scope and boundaries
ii. Normative references
iii. Terms and definitions
iv. Organization context
v. Leadership
vi. QMS planning
vii. Support
viii. Operation standard
ix. Performance evaluation
x. Improvement

Clauses 4 to 10 are the seven main clause of ISO 9001:2015 requirement and evaluation for the QMS is in appendix I. The ISO 9001:2015 is based PDCA which are:

1. P is plan: it is based on clauses 4, 5 and 6 which is context of organization, leadership and planning of QMS respectively.
2. D is do: it is clauses 7 and 8 which are support and operation of tiles production in WACC, Ajaokuta
3. C is check: it is clause 9 known as performance process on tile production

4. A is act: it is product and service improvement process which is clause 10

All of the clauses are linked to leadership which is clause 5.

The method adopted for QMS process auditing is based on compliance rating scale of 1 to 5:

1. None compliance
2. Poor compliance
3. Fair compliance
4. Good compliance
5. Excellent compliance

Quality Control Analysis

The tiles production phases are such as:

i. Mixing and drying phases
ii. Forming phase
iii. Glazing and firing phase
iv. Sorting and packaging phases

During the sorting and packaging of tiles, quality control process is adopted to select better quality without crack and ill dimension in WACC, Ajaokuta. P-chart was adopted for the analysis.

Result And Discussion

Results

Implementation's Level of TQM in WACC Using ISO-9001:2015 Standard

Table 1 stated the assessment of implementation level of WACC based on ISO-9001:2015 Standard in the year 2022.

Table 1: Implementation of ISO-9001:2015 Standard in WACC, Ajaokuta.

	Sub-clause requirement								
Clause No	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Compliance Rating**	**Compliance Remarks**
4. Context of organization	4	4	4	4	-	-	-	4.00	Good
5. Leadership	4	3	4	4	3	-	-	3.60	Good
6. Planning QMS	4	3	4	-	-	-	-	3.67	Good
7. Support	3	4	4	4	3	-	-	3.60	Good
8. Operation	4	4	3	3	3	3	3	3.29	Fair
9. Performance evaluation	4	4	3	-	-	-	-	3.67	Good
10. Improvement	3	3	3	-	-	-	-	3.00	Fair
Average compliance rating								3.55≅4.0	Good
Implementation based on Percentage								71%	Good

Note: None (1), Poor (2), Fair (3), Good (4), Excellent (5). – none clause requirement

The implementation of ISO-9001:2015 Standard in WACC, Ajaokuta was good during period of this research work. The score rating in Table 4.1 showed that 3.55 out of 5.0. Implementation of ISO-9001:2015 Standard based on percentage was at 71% in year 2022. Table 4.1 indicated that Clause 4 is requirement on context of organisation and compliance level was at good compliance. This means WACC, Ajaokuta was good in compliant requirement on understanding organisation and its context, understanding needs and expectations of interested parties; determination of scope of QMS; QMS and its processes for tiles production using ISO-9001:2015 Standard.

Table 1 indicated that Clause 5 is requirement on leadership and compliance level was at good compliance. This means WACC, Ajaokuta was good in compliant requirement on leadership and commitment, quality policy, organizational roles, responsibilities and authorities using ISO-9001:2015 Standard. Clause 6 is requirement on planning of QMS was at good compliance. This means WACC, Ajaokuta was good in compliant requirement on actions to address risks and opportunities, quality objectives and planning to achieve them, planning of changes using ISO-9001:2015 Standard.

Clause 7 is requirement on support and compliance level was at good compliance as in Table 1. This means WACC, Ajaokuta was good in compliant requirement on resources, competence, awareness, communication and documented information using ISO-9001:2015 Standard. Clause 8 is requirement on operation of the company, this was at fair compliance level. This means WACC, Ajaokuta was fair in compliant requirement on operational planning and control, determination of requirements for products and services, design and development of products and services, control of externally provided processes, products and services, production and service provision, release of products and services, control of nonconforming outputs using ISO-9001:2015 Standard.

Clause 9 is requirement on performance evaluation and compliance level was at good compliance as in Table 1. This means WACC, Ajaokuta was good in compliant requirement on monitoring, measurement, analysis and evaluation, internal audit and management review using ISO-9001:2015 Standard. Clause 6 is requirement on planning of QMS was at good compliance. This means WACC, Ajaokuta was good in compliant requirement on actions to address risks and opportunities, quality objectives and planning to achieve them, planning of changes using ISO-9001:2015 Standard.

Clause 10 is requirement on improvement and compliance level was at fair compliance as indicated in Table 1. This means WACC, Ajaokuta was fair in compliant requirement on determination of opportunities for improvement and necessary action to achieve the intended outcome of the Quality management system (General), nonconformity and corrective action and continual improvement using ISO-9001:2015 Standard. However, TQM in WACC using ISO-9001:2015 Standard indicated that WACC, Ajaokuta is ISO-9001:2015 certified company. The audit carried out by this study indicated ISO-9001:2015 was at 71%. Table 4.2 indicated the implementation outcome based on PDCA cycle.

Table 2: Implementation of ISO-9001:2015 Standard Using PDCA

	PDCA			
Clause	**P**	**D**	**C**	**A**
4. Context of organisation	4.00	-	-	-
5. Leadership	3.60	-	-	-
6. Planning of QMS	3.67	-	-	-
7. Support	-	3.60	-	-
8. Operation	-	3.29	-	-
9. Performance Evaluation	-	-	3.67	-
10. Improvement	-	-	-	3.00
Compliance Rating	3.76	3.45	3.67	3.00
Remarks	Good	fair	Good	Fair
Average compliance rating			3.47	Fair
Implementation based on Percentage			69.4%	

The implementation of ISO-9001:2015 Standard using PDCA in WACC, Ajaokuta showed that 3.47 out of 5.0 which was 69.4%. This based on outcome of implementation in the year 2022 as indicated in Table 2. The plan in PDCA involves the context of organisation, leadership and planning of quality management system and compliance rating was good compliance level at 3.76 out of 5.0 as indicated in Table 2. Do in PDCA involves operation and support of WACC, Ajaokuta to produce tiles and compliance rating was fair compliance level at 3.45 out of 5.0 as indicated in Table 2 in Check involves performance evaluation of WACC, Ajaokuta to produce tiles and compliance rating was good compliance level at 3.67 out of 5.0 as indicated in Table 2. However, the Act involves improvement of tiles production and management of tiles production with compliance rating of 3.0 out of 5.0 and this indicated fair compliance level. The business strategy plan by WACC, Ajaokuta was three (3) years according to Clause 4.1, therefore using linear regression to predict compliance rating of ISO 9001:2015 is stated in Table 3.

Table 3: ISO 9001:2015 Internal Audit Report on WACC, Ajaokuta

Year	Compliance Percentage Using ISO-9001:2015	
1(2014)	35.0	using ISO-9001:2008
3 (2016)	51.0	using ISO-9001:2008
6 (2019)	61.5	using ISO-9001:2015
8 (2021)	68.0	using ISO-9001:2015
9 (2022)	71.0	using ISO-9001:2015

The audit report of ISO implementation in WACC, Ajaokuta showed that year 2014 to 2019 quality was audited using ISO 9001:2008 before the upgrade into ISO 9001:2015 version. During ISO 9001:2015 internal audit report on compliance issue of quality management system, audited report on 2019 was at compliance level of 61.5%. There was none quality audit in the year 2020 and however, compliance level of ISO 9001:2015 was at 68%, 71% for the year 2021 and 2022 respectively. The implementation of ISO 9001:2015 took off by year 2019. Therefore, using the audit report of Table 4.3, linear regression of the compliance was:

$$P = 4.75x + 57.33 \quad (1)$$

where: P = Percentage compliance rating

x = Year after implementation of ISO 9001:2015

Since the business strategy plan by WACC, Ajaokuta was three (3) years the prediction of linear regression was plotted in Figure 1 to illustrate the compliance level.

From Figure 1 it was indicated that from implementation year 2019 of ISO 9001:2015 to year predicted year 2025, there will be compliance level of 62% and 86% respectively. This means significant improvement of 24% in WACC, Ajaokuta towards TQM implementation using ISO 9001:2015.

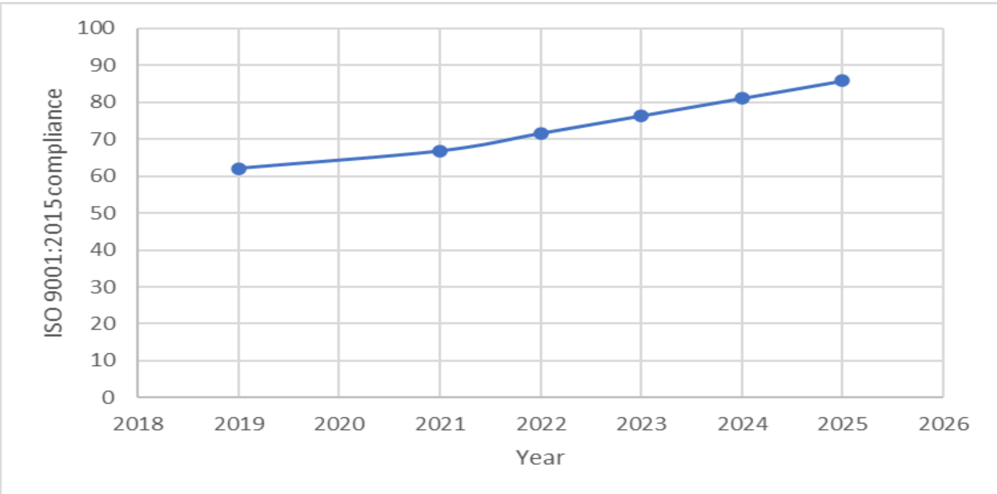


Figure 1: Compliance level of ISO-9001:2015 in WACC, Ajaokuta

Quality Control of Tiles Production

P-Chart Analysis

The quality control process of tile production in WACC, Ajaokuta are analysed based on daily productions using P-chart for different six (6) categories of tiles. Tiles production ranges from three (3) thousand (3000) to thirteen thousand (13000) daily. The categories of tiles production in WACC, Ajaokuta are: 40 x 80, 60 x 60, 120 x 60, 40 x 40, 25 x 40, 30 x 40 square centimetres

Table 4 illustrated that Quality control process (QCP) on tiles of 40 x 80 square centimetre which average daily production was 9500 tiles in WACC, Ajaokuta.

Table 4: QCP on Tiles of 40 x 80 square centimetres

Average Daily (D)	Average defective (p)	Defective ratio (r_p)
1	100	0.0105
2	30	0.0032
3	40	0.0042
4	130	0.0137
5	130	0.0137
Average	86	0.0091

QCP analysis of tiles production obtainable from Table 4 and include: Defective ratio, r_p = 0.0091

Daily Standard Deviation = 0.0102, Limit of upper control (UCL) = 0.0397 (3 defectives) and average defective tiles per day (86). Limit of lower control (LCL) = −0.0215 (0 defective and 2 product of tiles improvement). WACC, Ajaokuta requires working between ranges of 0 and 1 defectives per day for each of batch of 9500 tiles of 40 x 80 square centimetres produced. Figure 2 is the graph showing ratio of defective tiles per daily production of tiles of 40 x 80 square centimetre.

In the graph above the UCL indicated approximately 0.04 defective ratio and LCL is below 0 margin line. LCL of 0.02 indicated the reworking to have improvement on tiles. Table 5 illustrated that Quality control process (QCP) on tiles of 60 x 60 square centimetre in which average daily production was 5364 tiles in WACC, Ajaokuta.

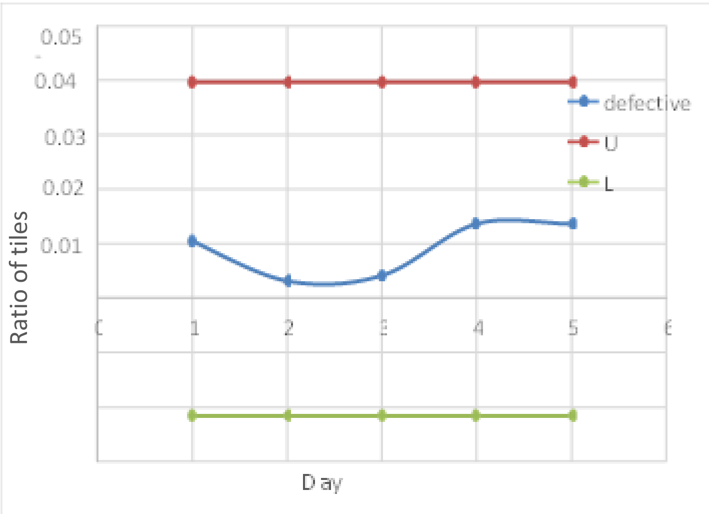


Figure 2: Plot of daily defective ratio in 40 x 80 sq. cm tiles

Table 4.5: QCP on Tiles of 60 x 60 square centimetres

Average Daily (D)	**Average defective** (p)	**Defective ratio** (r_p)
1	4	0.0007
2	5	0.0009
3	10	0.0019
4	2	0.0004
5	0	0.0000
Average	4	0.0008

QCP analysis of tiles production obtainable from Table 5 include: Defective ratio, rp = 0.0008, Daily Standard Deviation = 0.0141, Limit of Upper Control (UCL) = 0.0431 (0 defectives) and average defective tiles per day (4), Limit of Lower Control (LCL) = −0.0415 (0 defective). WACC, Ajaokuta requires working on zero (0) defectives per day for each of batch of 5364 tiles of 60 by 60 square centimetres produced. Figure 3 is the graph showing ratio of defective tiles per daily production of tiles of 60 x 60 square centimetre.

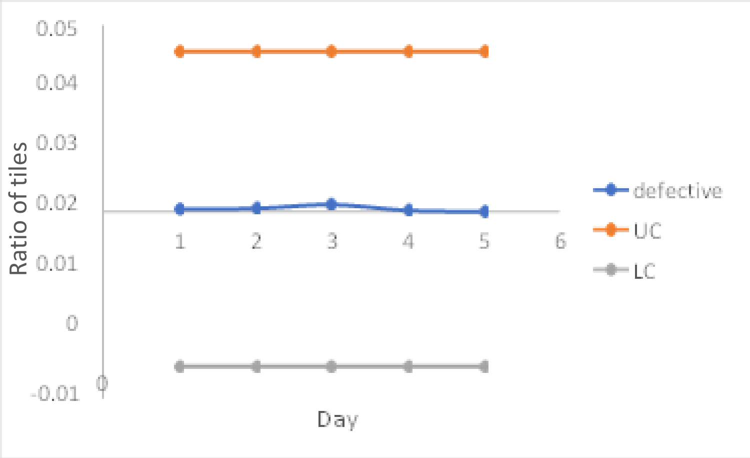


Figure 3: Plot of daily defective ratio in 60 x 60 sq. cm tiles

The graph in Figure 4.3 indicated that UCL was approximately 0.045 defective ratio and LCL is below 0 margin line. LCL of 0.04 indicated the reworking to have improvement on tiles production.

Table 6 illustrated that Quality control process (QCP) on tiles of 120 x 60 square centimetre in which average daily production was 7662 tiles in WACC, Ajaokuta.

Table 6: QCP on Tiles of 120 x 60 square centimetres

Average Daily (D)	**Average defective** (p)	**Defective ratio** (r_p)
1	150	0.0196
2	35	0.0046
3	50	0.0065
4	20	0.0026
5	95	0.0124
Average	70	0.0091

QCP analysis of tiles production obtainable from Table 4.4 include: Defective ratio, rp = 0.0091, Standard Deviation = 0.0113, Limit of Upper Control (UCL) = 0.0430 (3 defective) and average defective tiles per day (70). Limit of Lower Control $(LCL) = -0.0248$ (0 defective and 2 product of tiles improvement). WACC, Ajaokuta requires working between ranges of 0 and 3 defectives per day for each of batch of 7662 tiles of 120 x 60 square centimetres produced. Figure 4 is the graph showing ratio of defective tiles per daily production of tiles of 120 x 60 square centimetre.

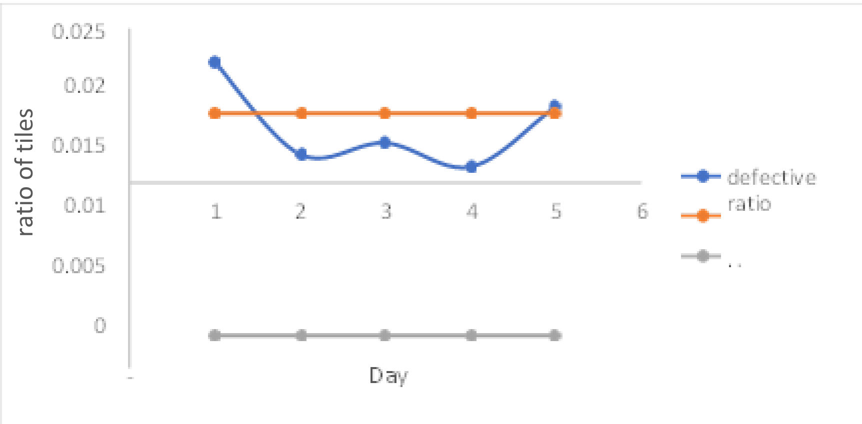


Figure 4: Plot of daily defective ratio in 120 x 60 sq. cm tiles

The graph in Figure 4 indicated that UCL was approximately 0.04 defective ratio and LCL is below 0 margin line. LCL of -0.025 indicated the reworking to have improvement on tiles production. Table 7 stated the Quality control process (QCP) on tiles of 40 by 40 square centimetre of Plate IV in which average daily production was 6851 tiles in WACC, Ajaokuta.

Table 7: QCP on Tiles of 40 x 40 square centimetres

Average Daily (D)	**Average defective** (p)	**Defective ratio** (r_p)
1	50	0.0073
2	53	0.0077
3	60	0.0088
4	40	0.0058
5	65	0.0095
Average	54	0.0078

QCP analysis of tiles production obtainable from Table 4.7 include: Defective ratio, r_p = 0.0078, Standard Deviation = 0.0120, Limit of Upper Control (UCL) = 0.0438 (2 defectives) and average defective tiles per day (54). Limit of Lower Control $(LCL) = -0.0282$ (0 defective and 2 product of tiles improvement). WACC, Ajaokuta requires working between 0 and 2 defectives per day for each of batch of 6851 tiles of 40 x 40 square centimetres produced.

Figure 5 is the graph showing ratio of defective tiles per daily production of tiles of 40 x 40 square centimetre. The graph in Figure 5 indicated that UCL was approximately 0.012 defective ratio and LCL is below 0 margin line. LCL of -0.0282 indicated the reworking to have improvement on tiles production.

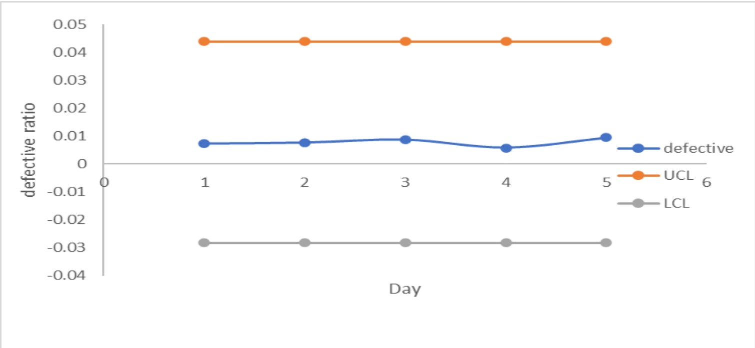


Figure 5: Plot of daily defective ratio in 40 x 40 sq. cm tiles

Table 8 stated the Quality control process (QCP) on tiles of 30 x 30 square centimetre in which average daily production was 13213 tiles in WACC, Ajaokuta.

Table 8: QCP on Tiles of 30 x 40 square centimetres

Average Daily (D)	**Average defective** (p)	**Defective ratio** (r_p)
1	26	0.0020
2	20	0.0015
3	13	0.0010
4	9	0.0007
5	12	0.0009
Average	16	0.0012

QCP analysis of tiles production obtained from Table 8 include: Defective ratio, r_p = 0.0012, Standard Deviation = 0.0087, Limit of Upper Control (UCL) = 0.0273 (0 defectives) and average defective tiles per day (16), Limit of Lower Control (LCL) = −0.0249 (0 defective)

WACC, Ajaokuta requires working between 0 defectives per day for each of batch of 13213 tiles of 30 x 40 square centimetres produced. Figure 4.6 is the graph showing ratio of defective tiles per daily production of tiles of 30 x 40 square centimetre.

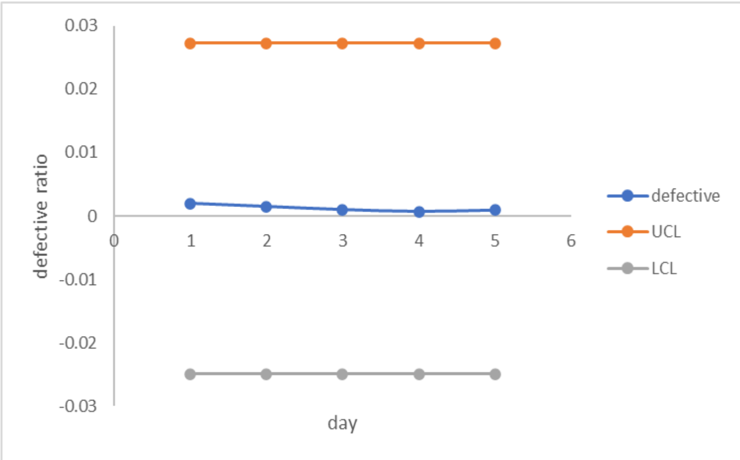


Figure 6: Plot of daily defective ratio in 30 x 30 sq. cm tiles

The graph in Figure 6 indicated that UCL was 0.027 defective ratio and LCL is below 0 margin line. LCL of -0.025 indicated the reworking to have improvement on tiles production. Table 4.9 showed the Quality control process (QCP) on tiles of 25 x 40 square centimetre of Plate VI in which average daily production was 12535 tiles in WACC, Ajaokuta.

Table 9: QCP on Tiles of 25 x 40 square centimetres

Average Daily (D)	**Average defective** (p)	**Defective ratio** (r_p)
1	20	0.0016
2	20	0.0016
3	25	0.0020
4	30	0.0024
5	15	0.0012
Average	28	0.0018

QCP analysis of tiles production obtainable from Table 4.9 include: Defective ratio, r_p = 0.0018, Standard deviation = 0.0080, Limit of upper control (UCL) = 0.0258 (1 defective). Limit of lower control (LCL) = −0.0222 (0 defective and 1 tile product improvement). WACC, Ajaokuta requires working between ranges of 0 to 1 defective per day for each of batch of 12535 tiles of 25 x 40 square centimetres produced. Figure 7 is the graph showing ratio of defective tiles per daily production of tiles of 25 x 40 square centimetre.

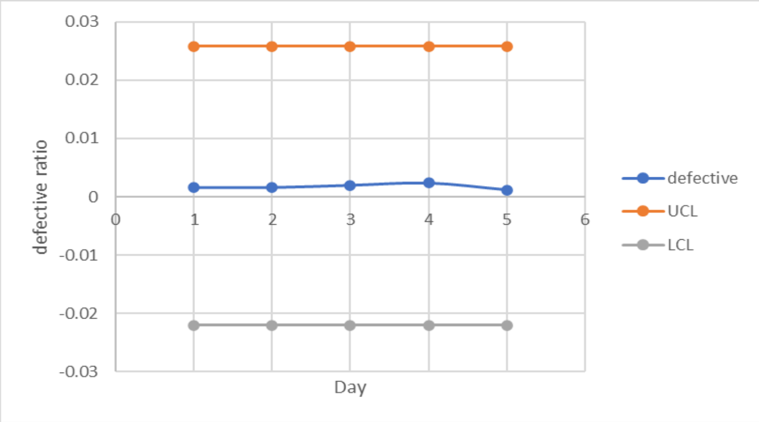


Figure 7: Plot of daily defective ratio in 25 x 40 sq. cm tiles

The graph in Figure 7 indicated that UCL was approximately 0.026 defective ratio and LCL is below 0 margin line. LCL of -0.022 indicated the reworking to have improvement on tiles production. The results from Table 4 – Table 9 indicated that WACC, Ajaokuta needs minimal reworking of the tiles production to be within maximum range of 0 to 3 defectives per daily batch production.

Operating Characteristics Curve (OCC)

The operation characteristics curve (OCC) is plotted based on percentage of acceptable defective number (z) for the whole tiles from Table 4 and Table 9 by using average defective of the tiles (p) and average daily tile production.

Z = 0.0015

The most defective tile profile was maximum of three tiles, therefore, n =3. P_r = = 0.9999

Zero defective, P_o = 0.9878; One defective, P_1 = 0.0001498; Two defectives, P_2 = 0.000001 and Three defectives, P_3 = 0.000000

Figure 8 shows that zero defective tiles will be almost acceptable by the consumers.

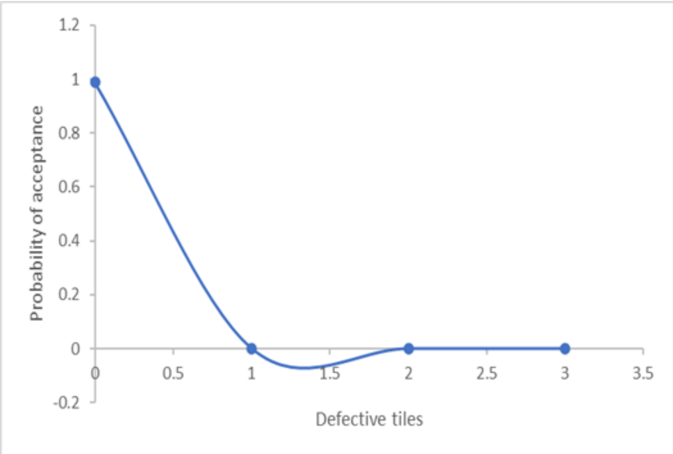


Figure 8: Tiles probability of acceptance by Consumer

From Figure 8 it was indicated that the maximum allowable acceptable tiles was per day from production and end consumer of the tiles will not accept such products. The graph showed that only zero defective tiles the consumer is willing to accept from WACC, Ajaokuta. To minimize of resources during production, the tiles above one defective will be reworked in the factory.

Discussion of Results

TQM in WACC using ISO-9001:2015 Standard shown in Table 4.1 indicated implementation level 71% in the year 2022. This means process of quality management that is include context of the organization, leadership, planning for the quality management, support, operation, performance evaluation and improvement was in good condition to improve continuous management and production of tiles in WACC, Ajaokuta. The PDCA in Table 2 also indicated 69.4% implementation of total quality management in the company and the company works on three years continual project improvement. The implementation of ISO 9001:2015 took off by year 2019 based on quality audit report and compliance rating, P regression equation was: $P = 4.75x + 57.33$ in which x is year after implementation of ISO 9001:2015.

WACC, Ajaokuta needs minimal reworking of the tiles production to be within maximum range of 0 to 3 defectives per daily batch production. The operating characteristic curve (OCC) indicated that only zero defective tiles the consumer is willing to accept from WACC, Ajaokuta.

Conclusion

The level of TQM implementation in WACC, Ajaokuta has improved quality process on tiles production in the recent. Therefore, the study concludes that TQM in WACC using ISO-9001:2015 Standard indicated implementation level of 71% in the year 2022. It was significant improvement to ensure quality management is in good condition for tiles production in WACC, Ajaokuta. Also, the six major categories of produced tiles in WACC, Ajaokuta had maximum three (3) defectives per daily batch production of three thousand to thirteen thousand for producing 40 x 80, 60 x 60, 120 x 60, 40 x 40, 25 x 40, 30 x 40 sq. cm tiles. WACC, Ajaokuta needs minimal reworking of the tiles production to be within maximum range of 0 to 3 defectives per daily batch production. Operating characteristic curve (OCC) indicated that consumer will accept none defective tiles.

References

Sila, 2007, Sahran *et al.,* 2010SON, 2015ISO 9001, 2015

Ahaotu, S.M. (2018). Effective Implementation of Total Quality Management within Nigerian Construction Industry. Manchester, UK: School of the Built Environment, University of Salford, PhD Thesis.

Awoku, R.Y.A (2012). An Empirical Study on Quality Management Practices, Organization Performance and Suppliers Selection in Southern Minnesota Manufacturing Firms (2012). Mankato, US: Minnesota State University, Cornerstone Publication, Msc Thesis in Manufacturing Engineering Technology.

Christensen, C., Betz, K.M. and Stein, M.S. (2014). The Certified Quality Process Analyst (2nd Edition). Milwaukee 53203, US: American Society for Quality (ASC), Quality Press, 64-67.

ISO-9000: International Organisation for Standardisation (2005). Quality Management System-Fundamentals and Vocabulary. *ISO 9000:2005,* 1-3.

ISO-9001: International Organisation for Standardisation (2008). Quality Management System. Geneva Switzerland: ISO Central Secretariat Chemin de Blandonnet Vernier, 15-18.

Maik, S.I. (2018). A Case Study of Total Quality Management Optimization Model for the Production of Corrugated Aluminium Sheets. Minna, Nigeria: Federal University of Technology, PhD Thesis in Mechanical Engineering.

Sahran, S., Zeinalnezhad, M., and Mukhtar, M. (2010). Quality Management in Small and Medium Enterprises: Experiences from a developing country. *International Review of Business Research Papers.* 6(6), 164 – 173.

Sila, I. (2007). Examining the Effects of Contextual Factors on TQM and Performance through the Lens of Organizational Theory: An Empirical Study. *Journal of Operations Management,* 25 (1), 83-109.

SON: Standard Organisation of Nigeria (2015). Standard Organisation of Nigeria Act. Visited and retrieved from www.lawpavilion/blog/standard-organisation.html on 25th June, 2021

SON: Standard Organisation of Nigeria (2021). SON Product Certification. Visited and retrieved from http;//SON.gov.ng on 25th June, 2021.Tauseef, A. (2012). *Total Quality Management and Six Sigma* (1st Ed.) Croatia: InTech Janeza Trdine, Croatia, 12-17.

Production of Pavement Blocks Using Low Density Polyethylene Product Waste

Aboje, A. A.[1 a]; Abbas, B. A.[2]; Kolo, D. N.[2]; Abubakar, M.[2]; Abdulsalam, A.[1b]

[1]*Chemical Engineering Department, Federal University of Technology, Minna, Nigeria*
[2]*Civil Engineering Department, Federal University of Technology, Minna, Nigeria*
[1a]*alen248@yahoo.com*, [1a]*bala.alhaji@futminna.edu.ng*, [1b]*daniel.kolo@futminna.edu.ng*, [2b]*mahmud1879@futminna.edu.ng*

Abstract:

Waste sachet water packs cause considerable land pollution in Nigeria. In this research, pavement block was produced using low density polyethylene products waste (sachet water packs) as an alternative binder. The production was achieved by first converting the sachet water packs into pellets and blending it with sandstone in a mass ratio of 8:2 (A), 7:3 (B) and 6:4 (C) sandstone to pellets respectively. The compressive strength, %water absorption and curing time tests were carried out on the pavement block to determine it suitability and safety for low-traffic use. The compressive strength for polymer concrete samples A, B and C were 13.65N/mm^2, 16.99N/mm2 and 20.34N/mm^2 respectively. After carrying out the %water absorption test on the polymer concrete A, B and C the following result was obtained: 8.33%, 5.47% and 4.03% respectively. It should be noted that the polymer concrete samples and the control samples which (are cement concrete based) are for light-traffic use (pedestrian, plazas, shopping complexes ramps, car parks, office drive ways, rural roads with low traffic, and residential road).

Keywords: Polyethylene, sachet water packs, Sandstone, Pellets, Pavement block

Introduction

Financial development and altering intake patterns have led to a rapid increase in the usage and consumption of plastics on the planet. It is on record that the consumption of plastic materials increased from about 5 million tons in the 1950s to well over 100 million tons in the 2000s (Wusu-Sekyere et al., 2013). Specialists have also warned that this growth will not decrease unless people revise how they use and recycle natural resources. There has actually been a tremendous improvement in efforts to turn waste to wealth worldwide. Nigeria produces an estimated 32 million tons of solid waste each year - among the highest quantities in Africa, and of this figure, plastic makes up about 2.5 million tons of heaps (Isioma, 2012). Through its waste management authority (LAWMA), Lagos State has carried the concern of filth that turned its environment into an eyesore by transforming the waste into different helpful materials (Owolabi & Amosa, 2010). Most plastics do not biodegrade. Instead, they gradually break down into smaller-sized fragments referred to as micro plastics which have more adverse effects on human health. Studies show that plastic bags and containers made of polystyrene foam could decay up to thousands of years, polluting soil and water (Mishra, 2016). Polymers have been utilized in building and construction as earlier as the 4th millennium B.C., when the clay brick walls of Babylonia were developed utilizing the natural polymer, asphalt in the mortar. The temple of Ur-Nina in the city of Kish had masonry foundations constructed with mortar made from 25 to 35% bitumen, a natural polymer (Hirde & Dudhal, 2016). Making use of polymers in building works is ending up being typical worldwide. Its physical characteristic as well as its relatively low expense makes it a commonly used construction material. The strength, toughness and aesthetically pleasing surface areas have made paving obstructs attractive for many industrial and community applications such as parking lot, pedestrian strolls and roads (Gencel, 2012). Water-retentive cinder block pavements are also utilized in locations often visited by lots of people consisting of sideways, parks, and plazas (Karasawa et al., 2006). Standard Portland cement concrete has several limitations, such as low flexural strength, low failure strain, vulnerability to frost damage and low resistance to chemicals. These restrictions are well recognized by the engineer and can generally be enabled in most applications. Polymer customized binders however show improved adhesion and cohesion (Sulyman *et al.*, 2016). Furthermore, cement is a main factor in high-energy use, CO_2 and dust emissions, and continuous ecological wear and tear (Koo et al., 2014). In addition, the importation of building materials has become difficult and expensive in the era of the COVID-19 pandemic which necessitates the use of alternative home-developed local materials. Even though concrete is a robust and reasonably durable structure material, it can become seriously compromised by poor manufacturing process or really aggressive environment. A variety of historical concrete structures display problems that are being resolved by applying polymers in concrete construction (Hing, 2008). Concrete pavement blocks (paver) have actually been in use for more than 50 years in Europe. Pavers have been used in heavy industrial port and airfield pavement from the 1970s in Europe (Abate, 1993). They were first produced in the Netherlands in 1924 and probably World War II led to the growth of concrete pavement blocks (Concrete Manufacturers Association, 2009). The objective of this research work was to convert waste into wealth by using waste water sachets (low-density polyethylene) to produce polymer modified pavement blocks suitable for applications in places such as light traffic pavements, parking lots and pedestrian strolls.

Materials And Methods

Materials

The materials used are mainly sachet water packs and sandstone. The sachet water packs serve as the alternative binder in place of cement. Whereas in contrast, the sandstone is the coarse aggregate.

Methods

Pretreatment and Size Reduction

Sachet water packs were collected from the environs of the Federal University of Technology Minna, Niger State. The sachets were evaluated, washed with cleaning agents remove and debris, sun-dried until absolutely no wetness existed, and then sorted. Size reduction or pelletizing was performed utilizing a 35-40kg shredding machine. The purpose of decreasing the size of the sachet water packs is to allow it to melt rapidly to attain the required molten state. Size reduction also allows harmony in the mixing stage because particles of similar size tend to blend quicker. After reducing the waste water sachets into smaller sizes, they are fed to a plastic pellet making maker. The plastic pellets making device is utilized to process and recycle waste plastics and make recycled plastic pellets. The waste plastic is squashed by a crusher and sent out to the feeder by an automated hoist and then the feeder feeds the material into the plastic pellets maker. After entering the plastic pellet mill, the product is re-plasticized and combined under the action of compression and external heating of the screw. With the increasing of temperature level and pressure, it presents a thick circulation state and is pressed to the head part. The plasticizer is cut into pellets by a "cutter". The plastic pellets are then cooled through the cooling system.

Mixing

The mixing was performed at various mixing ratio. The polymer block (Interlock) was produced using just the polymer pellets and sandstone. The mixing of sandstone to polymer was performed in the ratio of 8:2 (A), 7:3 (B), and 6:4 (C) respectively. This blend indicates that for the 8:2 blending, the mix consist of 80% sandstone and 20% low density polyethylene (LDPE) pellets, 7:3 mixing indicates 70% sandstone and 30% LDPE pellets. Lastly for the 6:4 mixing, we have 60% sandstone and 40% LDPE pellets. This is summarized in Table 1.

Table 1: Samples Composition

Samples	A	B	C
Compositions (standstone: pellets)	80:20	70:30	60:40

Heating and Cooling

After the desired mixing ratio was achieved, the mixture was poured into a stainless pot and heat was applied manually using coal. The heating process was carried out in other to melt the LDPE pellets into a molten state. The sachet water packs pellets were heated to a temperature of about 125 $°C$ which is the melting temperature for LDPE.

Moulding

The mould was fabricated in-house. The shape of the mould was that of an interlock pavement block. The uniform mixture of molten wax and sandstone was poured into the mould and allowed to take the shape of the mould. The essence of moulding is to give shape and size to the pavement block. The moulded polymer concrete composite was then immersed in water for about a minute in other for it to cool, and likewise solidify. Among the significant properties of LDPE is it capability to cool at a quick rate. The cooling process also helps to strengthen the molten wax mixture consequently providing it with the preferred shape and size. The cooling stage is the last step in producing the polymer-modified pavement block. The stages are captured in Figure 1.

Polymer Pellets and Sandstone

Heating stage

Molding stage

Final polymer modified concrete

Figure 1: Different Stages of the Polymer Concrete Production Process

Results And Discussion

Table 2 compares the compressive strength of the polymer pavement block samples produced with control samples, which are commercial pavement blocks produced with cement as a binder, and are of the same size and shape as the polymer pavement blocks produced. The compressive strength of the samples was determined using the equation

$$compressive\ strength\ (N/mm^2) = \frac{Crushing\ Load}{Area} \quad (1)$$

Table 2 shows the compressive strengths of each sample after curing (immersion in water) for 7, 14 and 28 days respectively. The compressive strength of a solid material helps to determine the maximum load it can withstand before failure. Of the many tests applied to the concrete, the compressive strength is the most important, as it gives an idea about the characteristics of the concrete. The higher the compressive strength of a material, the greater it ability to withstand a large load. Conversely, the lower the compressive strength of a material, the lower the amount of load it can withstand (Wang, 2006). Compressive strength was computed in conformity with BS8110 (2011). Figure 2 is a bar-chart representation of the information from Table 2. Again, A, B and C are the polymer-modified concretes produced with different mixing ratio of polymer to sandstone. For sample A, the mixing ratio was 80:20 (80% sandstone and 20% LDPE pellets) and the compressive strength was 13.58 N/mm^2 on average. For sample B, the mixing ratio was 70:30 (70% standstone and 30% LDPE pellets) and the compressive strength was 16.92 N/mm^2 on average. For sample C, the mixing ratio was 60:40 (60% sandstone and 40% LDPE pellets) and the compressive strength was 20.31 N/mm^2 on average. From the chart, it can be seen clearly that with an increment in the proportion of the LDPE pellets, the compressive strength of the sample increases.

Table 2: Sample compressive (N/mm^2) strength after curing for a given number of days

Samples	**7days Compressive Strength**	**14days Compressive Strength**	**28days Compressive Strength**
A	13.53	13.56	13.64
B	16.88	16.92	16.97
C	20.29	20.31	20.33
D_{cs}	2.31	2.50	3.12
E_{cs}	2.10	2.33	2.74

where D_{cs} = Control Sample D, and E_{cs} = Control Sample E.

Table 3: Individual Samples Water Absorption

Samples	**Water absorption (%)**
A	8.33
B	5.47
C	4.03
D_{cs}	19.64
E_{cs}	24.00

Nonetheless, the three polymer concrete samples all satisfy the minimum requirement for a Grade 10 (M10) concrete as according to BS8110 (2011) which is >10 N/mm^2. On the other hand, the control samples Dcs and Ecs have compressive strengths of only about 2.48 N/mm^2 and 2.35 N/mm^2 respectively. Recall that the control samples are the commercial grade samples. We can see that the compressive strengths of the control samples are way below the BS8110 (2011) standards, which speaks a lot about substandard products in Nigeria. Comparing the results of this research to other similar work in the literature, we see from the work of (Nwaigwe et al., 2019), that the compressive strength obtained from the polymer concrete was 10.5 N/mm^2. And also, the result obtained from the work of Agyeman et al. (2019), the compressive strength of the polymer sample was 8.53 N/mm^2. It should be noted that the concrete produced, i.e., the polymer sample and the control sample are for light-traffic (pedestrian plazas, shopping complexes ramps, car parks, office drive ways, rural roads with low traffic, residential roads, etc.). The different curing time for each sample gives an idea of the time it takes for each sample to reach it maximum strength after production. The essence of the curing time test is to determine whether the samples strength increases as it is been cured by water immersion. From the chart, we can see that the difference in the compressive strength of polymer samples A, B, and C after 7days immersion in water and crushing was 13.53 N/mm^2, 13.56 N/mm^2, and 13.64 N/mm^2 respectively, which is negligible. After 14 days of curing, polymer samples A, B, and C had the following compressive strength: 16.88 N/mm^2, 16.92 N/mm^2, and 16.97 N/mm^2, respectively. Finally, the compressive strength of the polymer samples A, B, and C after 28 days of curing was 20.29 N/mm^2, 20.31 N/mm^2 and 20.33 N/mm^2, respectively. From this, we can see that there is just little variation in the compressive strength of the polymer samples after the 7days, 14days and 21days curing time.

From this, we can deduce that the polymer pavement blocks gained most of their strength very quickly after production (i.e., they have a very short curing time). The control samples on the other hand vary significantly in their curing times. From figure 2 we can see the variation in the compressive strength of each control sample after 7, 14, and 28 days of curing, respectively. The compressive strength of control sample Dcs after 7, 14, and 28 days of curing was 2.3 N/mm^2, 2.50 N/mm^2, and 3.12 N/mm^2, respectively. Whereas control sample Ecs has the following compressive strength after 7, 14, and 28 days of curing: 2.10 N/mm^2, 2.33 N/mm^2, and 2.74 N/mm^2 respectively.

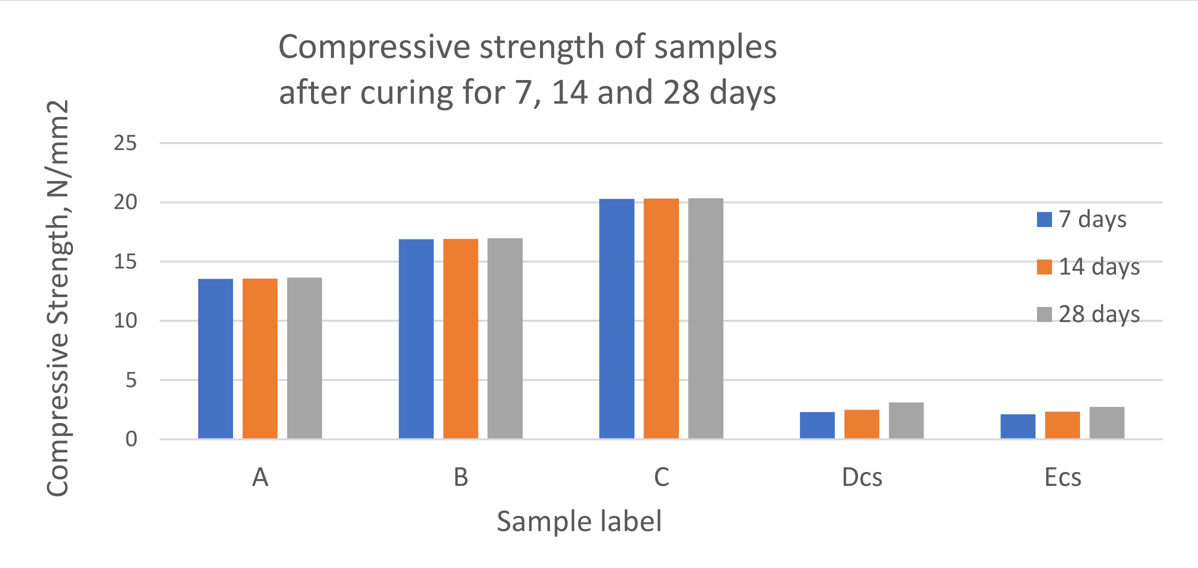


Figure 2: Compressive strength of each sample (N/mm2) after curing for a Number of Days

The results show how the cement pavement blocks takes a longer time to get cured, unlike the polymer modified concrete which gains 85% of its strength just 24 hrs after production. Table 3 presents the result of the %water absorption of each sample, and Figure 3 is a bar-chart representation of this result. The water absorption test aimed to determine the moisture absorption capacity of the various samples. The water absorption test was carried out by immersing each sample in water for 24h, after which the mass of the samples was taken. From figure 3 we can observe that polymer samples A, B, and C, had %water absorption of 8.33%, 5.47%, and 4.03% respectively. These values show a particular trend in the sense that greater the composition of polymer, the less water is absorbed. From the literature, the more a sample absorbs water, the higher it tendency to lose it structure thereby leading to failure. Sharma & Batra, (2021) stated that the water absorption for a pavement block should not be in excess of 7% by mass which is in line with ASTM D2171. From the chart, we can see that polymer sample A has water absorption of 8.33% which is a bit higher than what is stipulated by Sharma and Batra. Whereas polymer sample B and C meet the 7% water absorption requirement. On the other hand, the control samples Dcs and Ecs both have water absorption of 19.64% and 24% respectively which are both in excess of the 7% stipulated by Sharma & Batra, (2021). From the result obtained from the water absorption test, we can deduce that polymer pavement blocks absorb less water than the cement pavement block controls, making it very suitable for construction in a waterlogged site.

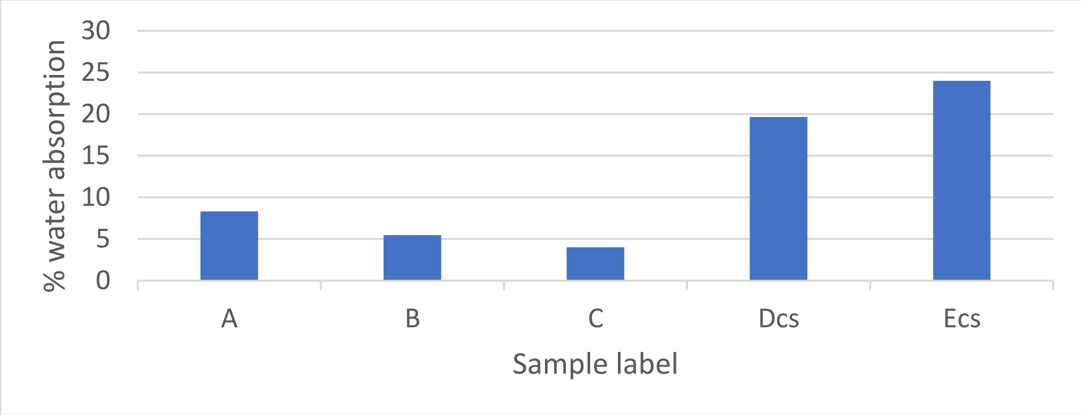


Figure 3: Water Absorption Chart of the Samples

Conclusions

This research produced pavement blocks using LDPE (sachet water packs) as an alternative binder. The modified pavement blocks produced from LDPE meet the required standard for light-traffic pavement in terms of compressive strength. The modified pavement block obtained from this research work is seven times stronger than the control samples, which were cement pavement blocks. The results from this research affirms that pavements blocks can be produced using polymers as alternative binders. Sachet water packs as we all know is one of the major sources of land pollution in Nigeria and it is also classified as waste which is dumped anywhere in the street. Producing pavements blocks from these sachet water packs will go a long way in reducing the pollution caused by the sachet water packs and also serve as a means of recycling, maximizing profit and reducing wastage. The perpetual increment in cement price in the country has led to substantial increment in the price of pavements blocks in the country. Using sachet water packs as the alternative binder will go a long way in reducing the cost of production of these pavers thereby making it affordable to the populace.

Acknowledgements

I would like to acknowledge the Department of Civil Engineering of the Federal University of Technology Minna for their generosity in permitting me to use their Laboratory. I also thank Mr Abiodun Emmanuel for his valuable effort in gathering of information and data collection.

References

Abate, L. M. (1993). An overview of Concrete paving blocks: Final technical report. Research projects T9903, task 3, subtask 3 TRAC special programs. Washington state transport centre (TRAC) University of Washington JD :10: University district building.

Agyeman, S., Obeng-Ahenkora, N. K., Assiaman, S., & Twumasi, G. (2019). Exploiting recycled plastic waste as an alternative binder for paving blocks production. Science Direct, 11(1), 246–256.

BS8110. (2011). Composition, Specifications and Conformity Criteria for Common Cements. British Standards Institution, London, UK.

Concrete Manufacturers Association. (2009). Concrete block paving manual.

Gencel, O. (2012). Properties of concrete paving blocks made with waste marble. Journal of Cleaner Production, 62–70.

Hing, E. (2008). Universiti Teknologi Malaysia Borang Pengesahan status Tesis. A report submitted in partial fulfillment of the requirements for the award of the degree of Bachelor of Civil Engineering Faculty of Civil Engineering.

Hirde, S. K., & Dudhal, O. S. (2016). Review on polymer modified concrete and its application to concrete structures. International Journal of Engineering Research, 5(3), 766–769.

Isioma, M. (2012). Lagos: Harvesting wealth from waste.

Karasawa, K., Ezumi, N., Kamaya, K., & Toriiminami, K. (2006). Evaluation of performance of water-retentive concrete block pavements. European International Journal of Science and Technology, 1(3), 233–242.

Koo, B. K., Jang-ho, J. K., Sung-bae, M., & Sungho, M. (2014). Material and Structural Performance Evaluations of Hwangtoh Admixtures and Recycled PET Fiber-Added Eco-Friendly Concrete for CO2 Emission Reduction. Materials, 7(1), 5959–5981.

Mishra, B. (2016). A Study on Use of Recycled Polyethylene Terephthalate (PET) as Construction Material. International Journal of Science and Research (IJSR, 724–730.

Nwaigwe, D. N., Sulymon, N. A., Bello, T., & Amiara, C. A. (2019). An Investigation into the properties of concrete containing polyethylene (pure water sachet waste). International Journal of Engineering Trends and Technology, 67(8), 5550–5562.

Owolabi, R. U., & Amosa, M. K. (2010). Laboratory Conversion of Used Water Sachet (polyethylene) to Super Wax/Gloss like Material. International Journal of Chemical Engineering and Applications, 1(1), 2022–2032.

Sharma, S. M., & Batra, G. (2021). Effect of water absorption on mechanical and technological properties of Indian ramie/epoxy composites. Proceeding of the Institution of Mechanical Engineers, Part J: Journal of Engineering Tribology.

Sulyman, M., Haponiuk, J., & Formela, K. (2016). Utilization of recycled polyethylene terephthalate (PET) in engineering materials. International Journal of Environmental Science and Development, 7(2), 206–418.

Wang, R. (2006). Influence of polymer on cement hydration in SBR-modified cement pastes. Cement and Concrete, 36(1), 1744–1751.

Wusu-Sekyere, E., Issaka, K., & Abdul-Kadri, Y. (2013). An Analysis of the Plastic Waste Collection and Wealth Linkages in Ghana. International Journal of Current Research, 5(1), 205–209.

Effect of Partial Replacement of Cement with Cow Dung Ash Using Bida Natural Coarse Aggregate

Abbas, B. A.[1], Yusuf, A.[1], [1]Kolo, D. N., Aboje, A. A.[2], Mahmud, M.B.[3] & Ndaiji, A. U.[3]
[1]Department of Civil Engineering, Federal University of Technology, Minna
[2]Department of Chemical Engineering, Federal University of Technology, Minna
[3]Department of Civil Engineering, The Federal Polytechnic Bida
e-mail: bala.alhaji@futminna.edu.ng; (08065260435, 08058890435)

Abstract

The research investigates the effect of partial replacement of cement with cow dung ash (CDA) in concrete production using Bida natural coarse aggregate. Water to cement ratio and mix ratio of 0.6 and 1:2:4 was adopted respectively. The aggregates used were characterized and the cow dung was calcined at a temperature between 400-500oC. Concrete was produced using CDA as cement replacement at 0%, 5%, 10%, 15%, 20%, 25%, 30%, 35% and 40%. Slump of the freshly produced concrete was determined and the compressive strength of the hardened concrete was determined at 7, 21 and 28 days of curing. The sum of SiO2, Al2O3 and Fe2O3 in CDA exceeds the 70% minimum specified by ASTMC 618-12. The slump of the fresh concrete ranges from 0 – 40 mm while the compressive strength at 28 days curing duration ranges from 12.59N/mm2 19.29N/mm2 and density was 2323.95kg/m^3– 2554.59kg/m^3 respectively. The test results revealed that the compressive strength decrease with increase in CDA content and increase with curing age. The strength results indicate that there was no much significant difference between the control specimen with 0% CDA and that containing 5% CDA. This implies that concrete made using CDA as partial replacement for cement can be used for structural applications such as in the construction of reinforced concrete slabs, beams, columns and foundations. The study concluded that CDA has pozzolanic properties and can be used to replace up to 10% cement in concrete produced using Bida natural coarse aggregate.

Keywords: *Concrete, Cement, Cow dung Ash, Compressive Strength, Workability*.

Introduction

Concrete is one of the most widely used construction material worldwide and there is an increase in the production of concrete to meet the ever-increasing demand for housing and other infrastructure. Concrete is a composite material consisting of aggregate (gravel and sand), cement, and water. Concrete is one of the construction materials which determine the strength, durability and structural performance of most construction work. Concrete is a man-made composite, a major constituent of which is natural aggregate such as gravel and sand or crushed rock (Alhaji, 2020. Alternatively, artificial aggregate such blast furnace slag, expanded clay, broken bricks and steel shots may be used where appropriate. The hardened concrete may be considered as an artificial stone in which the void of larger particles (coarse aggregate) is filled by the smaller particle (fine aggregate) and void of fine aggregate are filled with cement. The cementitious material and water form a cement paste which in addition to the filling of the void of fine aggregate coats the surface of fine and coarse aggregate together to form a compact mass. Concrete occurs in both fresh and hardened state. It fresh state must undergo proper workability, consistence, setting, handling, placing, transportation and compaction for it to be satisfactory. This fresh concrete solidified and hardened after placement and develops strength over time (Olaniyan, 2001). As a construction material, concrete can be cast in almost any shape desired, and once hardened, can become a structural (load bearing) element.

Cement, which is the main binder in the production of concrete, mortar, sandcrete blocks and other cement-based products, is very expensive particularly in developing countries (Awoyinfa, 2013). The activities of cement producing companies have depleted the natural environment and huge amount of poisonous gases such as Carbon dioxide CO_2, NO2, are released into the atmosphere causing environmental pollution. These gases are also responsible for depletion of the ozone layer which is responsible for global warming (Shalini, *et al.*, 2006).

Portland cement is the most common type of cement in general use around the world, used as a basic ingredient of concrete and mortar. It was developed from other types of hydraulic-lime in England in the mid-19th century and usually originates from limestone. It is a fine powder produced by heating materials in a kiln to form what is called clinker, grinding the clinker, and adding small amounts of other materials. Several types of Portland cement are available with the most common being called ordinary Portland cement (OPC) which is grey in color, but a white Portland cement is also available, Portland cement is caustic so it can cause chemical burns, the powder can cause irritation or with severe exposure lung cancer and can contain some hazardous components such as crystalline silica and hexavalent chromium. Environmental concerns are the high energy consumption required to mine, manufacture, and transport the cement and the related air pollution including the release of greenhouse gases, dioxin, NO2, SO2, and particulates (Yong & Ouhadi, 2007).

The low cost and widespread availability of the limestone, shales, and other naturally occurring materials used in Portland cement make it one of the lowest-cost materials widely used over the last century throughout the world. Concrete produced from Portland cement is one of the most versatile construction materials available in the world.

Cow dung is basically the rejects of herbivorous matter which is acted upon by symbiotic bacteria residing within the animal's rumen. Cow/Cattle are mostly found in every part of Nigeria while they are mostly breed in the northern states of the nation such as Niger State, Plateau state, Nassarawa state, Kaduna state and Jigawa state. (Olawale and Suley, 2012).

Cow dung comprises of organic matter including fibrous material that passed through the cow's digestive system, among other liquid digester that has been left after the fermentation, absorption and filtration, then acidified, then absorbed again. Exact chemical composition is of mostly carbon, nitrogen, hydrogen, oxygen, phosphorus, etc. with salts, cells sloughed off as the digester went through the digestive tract, some urea, mucus, as well as cellulose, lignin and hemicelluloses (Pavan *et al.,* 2012).

A full-grown well-fed cow produces between 10-15kg of cow dung per day which contains about 28% water in its fresh state and 34% ash when calcined (Olusegun and Sam, 2012). The world cattle population is estimated at 1.4 billion (Food and Agricultural Organization, 2010). Nigeria has an estimated cow population of 16 million and is expected to produce an estimated 264,000tons of cow dung per day (Salisu, 2007). In many parts of the world, cow dung is predominantly used as green manure for farming. It is also used with adobe in brick production, insect repellant and more recently used to produce biogas (Marek, 2012) for electricity and heat generation. It can be noted that despite its application in the aforementioned areas, its production outweighs the usage (Olusegun and Sam, 2012)

Cow dung was habitually used in concrete and recent publications suggest that dung may improve workability and durability or may act as an additional binder. Knowledge has also been lost as to whether fresh, old, or weathered dung was used. Since there is no historic reference to the dung being old or weathered, it is conceivable that this is a recent invention resulting from modern attitudes toward odour and hygiene. In any case, dried and fresh dung differ mainly in the water content and so are likely to affect only the amount of water, if any, added during mixing of the concrete. This illustrates the literature of the active cow dung component in concrete.

Materials nd Methods

Materials

The material used includes Ordinary Portland Cement (OPC), Cow Dung Ash (CDA), clean river Sand, Bida Natural Coarse Aggregate and water. (The material preparation took place at the Civil Engineering Department Laboratory of the Federal University of Technology, Minna.

River sand: The natural sharp sand used were extracted from Gidan Mangoro, Minna, Niger state. The sample collected were air-dried inside the civil engineering laboratory to enhance better concrete production. the sharp sand was clean, well graded in accordance with the set requirements of ASTMC 114, standard specification of aggregate for conventional concrete.

Cement: The Cement used for this research work is Ordinary Portland Cement obtained from an open market in Gidan Kwano Minna.

Cow dung: was obtained from the University farm in the Campus. The cow dung was exposed to sunlight to dry in order to have dung cakes which was subjected to burning within the university premises in Gidan Kwano campus after it was dried to have the cow dung ash. The resultant ash was grinded into finer particle using mortar and pestle and was sieved using sieve 75mm size.

Coarse aggregate: Bida Natural Coarse aggregate (Plate I) were used and obtained from Bida town Niger State in Nigeria. The aggregate was passed through a set of sieves to know their actual sizes. The aggregates that pass-through BS sieve 20mm and retained on BS sieve 14mm to 5mm were used for the research work.

Plate I: Bida natural stone

Methods

The Methodology include Laboratory experiment and this consist of preparing and testing of fresh and hardened concrete specimen of normal concrete and CDA concrete, All the samples were tested based on laboratory preliminary test with Sieve Analysis of fine aggregate and coarse aggregate, Specific gravity of fine aggregate and coarse aggregate, Slump test and Compressive strength test carried out according to standard specification.

A total of 81 concrete cubes of 150mm x 150mm x 150mm dimension were cast. The percentages of substituting the cement with CDA varied at 0%, 5%, 10%, 15%, 20%, 25%, 30%, 35% and 40% of Cement and values of their respective compressive strength were taken at 7days, 21days and 28days of hydration periods.

The compressive strength of the Sample was determined after the specific curing periods and demoulding according to Standard Specification.

Production of Concrete specimen: Moulds of (150×150×150) mm^3 were used. They were lubricated with engine oil in order to reduce friction and to enhance removal of cubes from the moulds. They were then filled with concrete in three layers and each layer was tamped 25 times. The moulds containing the cubes were left for 24 hours under a room temperature for the cubes to set before removing the mould. The cubes were removed after 24 hours and were taken to curing tank (BS EN 12390, 2002).

Curing of Concrete Cubes: The method use for curing in this work is the total immersion of the cubes in water for specific age of 7, 21 and 28 days from the day of casting (BS EN 12390-2:2000)

Compressive Strength Test: The concrete cubes were crushed at 7, 21, and 28 days in order to determine the compressive strength of the cubes. The compressive strength in N/mm^2 is determined by dividing the maximum of failure load of the specimen during the test by the cross-sectional area of the specimen, BS EN 12390 (2002). Compressive strength is evaluated using Equation 3.1

$$Copressive\ Strength = \frac{Crushing\ Load}{Cross\ sectional\ Area} \quad (1$$

Results And Discussion

Results of physical properties

Table 1: Physical Properties of the Aggregates

Parameter	Sand	Bida Gravel	Cow dung	Cement
Specific gravity	2.56	2.61	2.53	3.15
Natural moisture content	4.94	2.02	-	-
Compacted Bulk density (kg/m^3)	1615.10	1786.46	-	-
Uncompacted bulk density (kg/m^3)	1460.30	1640.16	-	-
Void ratio	0.90	0.92	-	-

Results of sieve analysis

Table 2: Sieve analysis of Fine aggregate (Sand).

Sieve size (mm)	Weight of sieve (g)	Weight of sieve + sample retained (g)	Weight of sample retained (g)	Percentage of sample retained (%)	Cumulative percentage retained (%)	Percentage of sample passing (%)
5.000	476.65	480.2	3.55	1.11	1.11	98.89
3.350	468.63	481.9	13.27	4.14	5.25	94.75
2.360	427.72	450.5	22.78	7.10	12.35	87.65
2.000	418.46	430.3	11.84	3.69	16.04	83.96
1.180	386.46	433.0	46.54	14.51	30.55	69.45
0.850	354.45	385.2	30.75	9.58	40.13	59.87
0.600	468.38	508.6	40.22	12.54	52.67	47.33
0.425	435.51	461.7	26.19	8.16	60.83	39.17
0.300	312.55	335.1	22.25	7.03	67.86	32.14
0.150	421.11	464.2	43.09	13.43	81.29	18.71
0.075	372.75	397.9	25.15	7.84	89.13	10.87
Pan	270.89	305.8	34.91	10.88	100	0

Table 3: Sieve analysis of Coarse Aggregate (Bida Gravel)

Sieve size (mm)	**Weight of sieve (g)**	**Weight of sieve + sample retained (g)**	**Weight of sample retained (g)**	**Percentage of sample retained (%)**	**Cumulative percentage retained (%)**	**Percentage of sample retained (%)**
28	1.61	1.61	0.00	0.00	0.00	100.00
20	1.48	1.51	0.03	2.97	2.97	97.03
14	1.42	2.07	0.68	64.36	67.33	32.67
10	1.37	1.61	0.24	23.76	91.09	8.91
5	1.50	1.59	0.09	8.91	100	0
Pan	0.83	0.83	0.00	0	100	0

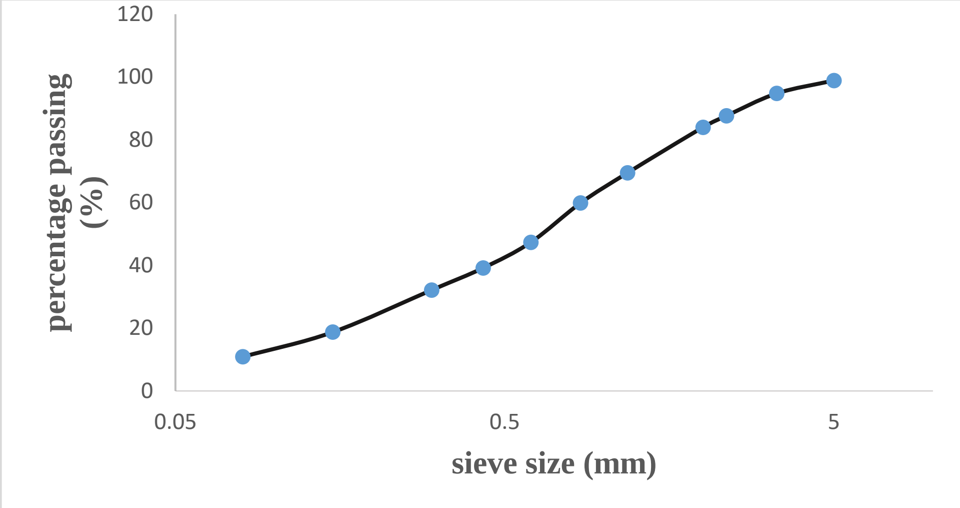


Figure 1: Particle Size Distribution of Fine Aggregate (Sand)

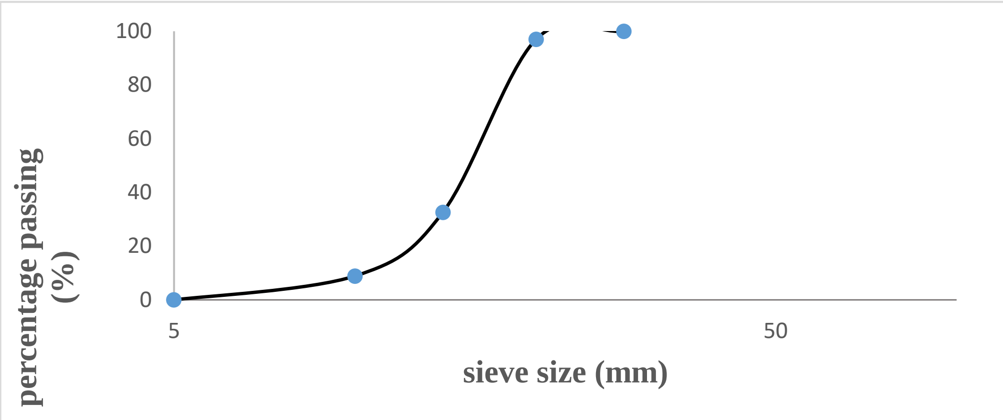


Figure 2: Particle Size Distribution of Coarse Aggregate (Bida Gravel)

Chemical Composition of CDA

Table 4: Chemical Composition of CDA

Element	Composition (%)	ASTM C618-12 Requirement
Na_2O	0.926	
MgO	3.659	
Al_2O_3	9.785	
SiO_2	64.65	$SiO_2+Al_2O_3+Fe_2O_3 \geq 70\%$
P_2O_5	3.449	
SO_3	1.990	
Cl	0.791	
K_2O	2.626	
CaO	7.416	
TiO_2	1.068	
Cr_2O_3	0.002	
Mn_2O_3	0.183	
Fe_2O_3	3.365	
ZnO	0.021	
SrO	0.060	

Discussion of result of physical properties of aggregate

The result of specific gravity, bulk density (compacted and uncompact) and moisture content are presented in Table 1. The specific gravity of Bida natural stone, Cow dung ash, fine aggregate are 2.61, 2.53 and 2.56 respectively. This value obtained fall within the limit for natural aggregate 1.3-3.0 and 2.6-2.7 respectively. It implies that aggregate can be conveniently use for construction work (concrete) without much need for mix proportioning adjustment (Naville, 1995). The specific gravity of CDA is 2.53, which is also close that of Ordinary Portland cement. This in an indication that CDA can therefore be suitable for substitution of cement for concrete production.

The bulk density: result is 1640.16kg/m³ (uncompacted) and 1786.46kg/m³ (compacted) for Bida natural stones, which classified Bida natural stones as normal weight aggregate, Table 1. Also the compacted and uncompacted bulk density of sand are 1615.10kg/m^3 and 1460.30kg/m^3 which agree with the value of 1625kg/m^3 and 1542.00kg/m^3 report by Alhaji (2020)

Sieve analysis: The result obtained for sieve analysis of both sharp sand and gravel was recorded as shown in Tables 2.0 and 3.0. However, from Figure 1.0 the curve shows as S-curve showing that the sharp sand is well graded and therefore, adequate for producing a workable concrete. Also, Figure 2.0 shows a smooth grading curve which is an indication that the Bida aggregate is adequate for production of workable concrete.

Chemical analysis of CCA: Table 4.0 shows the chemical composition of cow dung ash. The total percentage composition of iron oxide (Fe_2O_3=3.365), Silicon dioxide (SiO_2=64.65) and Aluminum oxide (Al_2O_3=9.785) was found to be 77.8%. The value is within the required value of 70% minimum for Pozzolanas as specified by ASTM C618 (2005). This value is little more than the value obtained by Alhaji (2006) for Corn cob ash (CCA) (72.4%) which implies that Cow dung ash (CDA) is more pozzolanic.

Results of Concrete properties

Slump test

Table 5: Result of slump test of a fresh concrete

% Replacement of Cement with CDA	Concrete Mix	Water/Cement Ratio	Slump (mm)	Slump type
0	1:2:4	0.60	40	True
5	1:2:4	0.60	35	True
10	1:2:4	0.60	30	True
15	1:2:4	0.60	25	True
20	1:2:4	0.60	15	True
25	1:2:4	0.60	10	True
30	1:2:4	0.60	5	True
35	1:2:4	0.60	0	Zero
40	1:2:4	0.60	0	Zero

Compressive strength of concrete

Table 6: Summary of Average 7-, 21- and 28-Days Compressive strength of Concrete with varied percentage Replacement of Cement with Cow dung ash

S/No	% Replacement	Average Compressive strength (N/mm^2) 7days	Average Compressive strength (N/mm^2) 21days	Average Compressive strength (N/mm^2) 28days
1	0	12.81	18.92	19.29
2	5	12.42	18.18	18.43
3	10	12.01	17.18	17.94
4	15	9.81	15.79	16.72
5	20	8.59	15.42	15.80
6	25	6.63	14.86	15.32
7	30	6.59	14.15	14.93
8	35	6.52	13.13	14.83
9	40	6.31	12.49	12.59

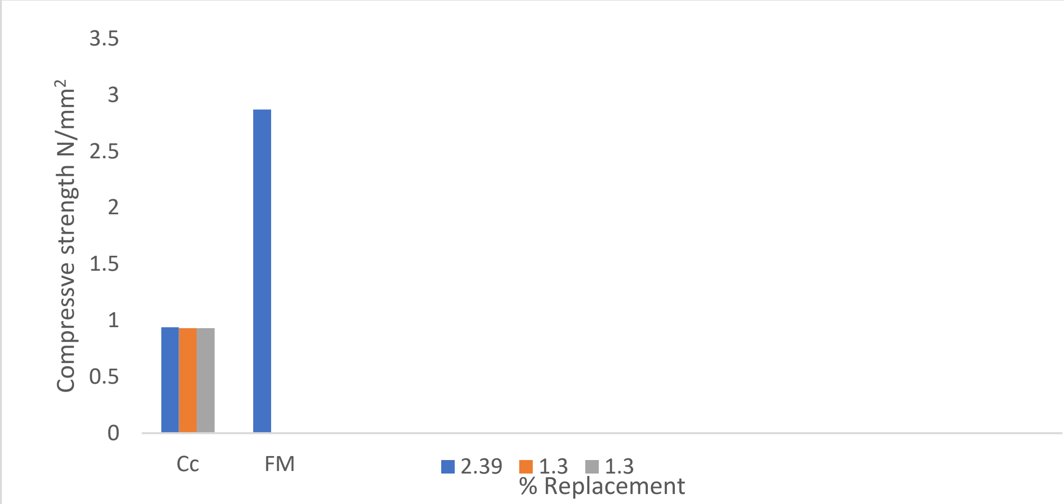


Figure 3: Compressive strength against % Replacement

Dry density

Table 7: Summary of Average 7-, 21- and 28-days Dry Density of Concrete with varied percentage Replacement of Cement with Cow dung ash

S/No	% Replacement	Average Dry Density (kg/m^3) 7days	Average Dry Density (kg/m^3)21days	Average Dry Density (kg/m^3)28days
1	0	2450.37	2579.03	2596.54
2	5	2423.70	25700.24	2590.62
3	10	2413.95	2529.38	2488.89
4	15	2381.60	2510.75	2439.51
5	20	2360.12	2403.95	2379.13
6	25	2345.43	2396.05	2367.04
7	30	2327.72	2359.63	2327.35
8	35	2300.12	2341.07	2267.04
9	40	2283.95	2303.46	2127.35

Discussion of result of slump test, Compressive strength and Dry density of a concrete

Slump test: The result of slump is presented in Tables 5. The result shows that workability of concrete reduced with increasing CDA content. Hence reduction in workability observed in this research work is a true reflection of the physical properties of material constituent explained above. Thus, mix with 0% and 30% replacement gave a true slump and these mix with 35% and 40% provided a zero slump, meaning that the effect of admixtures toward workability was inversely proportional to the CDA content.

Compressive strength: The result of compressive strength and dry density are as shown in Table 6, the strength increases as the curing age increases. This is primarily due to the fact that concrete hardening is caused by chemical reaction between cement and water which continues for a long period of time and consequently, concrete get stronger with age (Gambir, 2004)**.** The range of value of compressive strength for normal strength concrete is $20N/mm^2$-$40N/mm^2$. It was also observed that the strength decreases along with the increment of the Cow dung ash, this behaviour is also a true reflection of lower binding ability of Cow dung as compare with Ordinary Portland cement, thus the substitution of which leads to a reduction in the strength of the concrete. However, the result of percentage replacement at 5% with compressive strength of $18.43N/mm^2$ is very closer to the lower limit of normal strength concrete which is the optimum replacement and can be used for structural purpose such as reinforced concrete slab, beam, column and foundation with minimum adjustment in the factor of safety.

Dry density: The result of dry density is as shown in Table 7. Dry density of the concrete is within the range of 2596.54- 2127.35kg/m^3 for mix 0%-40% and respectively. However, based on the research reported by Agede and Manasseh (2009) who stated that those concrete with dry density between 300 – 800kg/m^3 can be classified as low-density concrete, those between 960-1300kg/m^3 are moderate strength concrete and the once having density in the range of 1350-1900kg/m^3 are structural light weight concrete. while Normal weight concrete are these with density of 2200-2600kg/m^3 (Agede and Manasseh, 2009). Hence the concrete with mixes 0% to 40% with dry density as stated above can be classified as Normal weight concrete

Conclusion

Based on the results of the research, the following conclusion are made;

1) The chemical composition of cow dung ash as shown that it can can be classified as a class N pozzolana according to ASTM C618-2012 specification.

2) The Strength Activity Index of CDA is 77.8% which exceeds the 70% minimum set by ASTM C618-2012 and thus CDA can be used as a Supplementary Cementitious Material for mortar and Concrete Production

3) The use of CDA as cement replacement in concrete has the potential to reduce the risk of late expansion

4) Compressive strength decreases as the CDA content increases and increases as the curing period is prolonged.

5) With strength as a criterion, CDA of no more than 5% can be used to produce good and quality mortar and concrete.

6) Cow dung ash addition of no more than 5% resulted in significant long-term increase in compressive Strength.

Recommendations

From conclusion drawn in this research work, it is therefore recommended that;

1. Cow dung ash can be used as a partial replacement of cement (5%) especially in places where is in abundance.

2. Concrete should be properly cured to the achieve properties of design strength, durability and long-lasting serviceability.

References

Awoyinfa, S. (2013). Cement prices still defies law of supply and demand. *Punch*- Newspaper'. Retrieved_fromhttp://www.punhing.com>home>feature.

Alhaji, B. (2020) Suitability of periwinkle shell as partial replacement of Bida natural stone in concrete production. 2nd International Civil Engineering Conference (ICEC 2020). Federal University of Technology, Minna, Nigeria. Pp 463-470

Bunici, H. & Aksogan, O. (2006). Sulfate
resistance of plain and blended cement. Cement and concrete composite, vol 28.

Degirmenci, N., Okucu, A. & Turabi, A. (2007). Application of phosphogypsum in soil stabilization, Building and Environment, Volume 42, Issue 9, Pages 3393-3398.

Dermatas, D. & Meng, X. (2003). Utilization of fly ash for stabilization/solidification of heavy metal contaminated soils, Engineering Geology, Volume 70, Issues 3-4 , 377-394.

Garg Anil Kumar & Mudgal, V. (2007). Organic and mineral composition of Gomeya (cow dung) from desi and crossbred cow" . International Journal of Cow Science, 2007. Volume:3, Issue: 1 & 2,

Ghassan, K. L., Meun, A. & Panagustos, G.A. (2013). Natural pozzolana as a partial substitue for cement in concrete.

Goktepe, A. B., Sezer, A., Sezer, G. I. & Raymar, K. (2008). Classification of time-dependent unconfined strength of fly ash treated clay. Construction and Building Materials, Volume 22, Issue 4, 675-683.

Guney, Y., Sari, D., Cetin, M. & Tuncan, M. (2007). Impact of cyclic wetting drying on swelling Behaviour of lime stabilized soil. Building and Environment, Volume 42, Issue 2, 681-688.

Harsdorff, M. (2012). The Economics of cowdung; Creating green jobs in tne dairy industry in India. India: (Tech. Report). International labour Organization.

K. O. Olusola, E. A. Olanipekun, O. Ata, O. T. Olateju (2006). Department of Building, Obaafemi Awolowo University, Ile-Ife, Osun State, Nigeria. Studeis On termite hill and lime as partial replacement for cement in plastering Building and Environment 41, 302-306.

Ketkukah, T. S. & Ndububa, E. E. (2006). GorundNut Husk Ash (Gha) As a Partial Repalcement of Cement in Mortal Department of Civil Enginnerung Technology. Nigerian Journal of Technology Vol 25, No. 2.

Misra, A., Biswas, D. & Upadhyaya, S. (2005). Physico-mechanical behaviour of self-cementing class C fly ash clay mixtures, Fuel, Volume 4, Issue 11, *2003 Internation Ash utilization Symposium, 1410-1442.*

Olawale Ajibola, O. & Eniola, O. S. (2012). Cow Dung - Water Hyacinth sludge: A Veritable Source of Renewable Enegy. Journal on Sustainable Development and Environment Protection, 2(1).

Olusegun, A. A. (2012). Methanol from Cowdung. Journal of Environment and Earth Science Vol 2, No. 7, 9-16.

Ouahadi, V. R. & Yong, R. N. (2008). Ettringite formation and behaviour in clay soils. Applied clay science. Volume 42, 258-259.

Papadakis, V. G. & Tsimas, S. ((2002)). Supplementary Material in Concrete. Part 1. Efficiency and design. Cement and concrete research, vol 32.

Pavan VSR, Kumar, R. & PoluRaju, P. (2012). Incorporation of Cow ung Ash to Mortar and Concrete. International Journal of Engineering Research and Applications (IJERA), 2(3):580-585.

Pavan, V., Kumar, R. & PoluRaju, P. (2012). Incorporation of Cow dung Ash to Mortal and Concrete.Internationla Journal of Engineering Research and Application (IJERA).

Rajasekaran, G. (2005). Sulfate attack and ettringite formation in the lime and cement stabilized marine clays. Ocean Engineering Volume 32, 1133-1159.

Salisu, N. (2007). Cattle in the News. http://www.gamji.com/article4000/NEWS.

Shalini, A., Prem, V. A. & Dahiya, R. P. (2006). Application of a system dynamics approach for assessment and mitigation of CO2 emissions from cement industry. Journal of Environmental Management, 79, 383-398.

Wild, S., kinuthia, J. M., Jones, G. I. & Higgins, D. D. (1998). Effect of partial substitution of lime with ground granulated blast furnace slag (GGBS) on the strength properties of lime-stabilised sulphate-bearing clay soils. Engineering Geology, Volume 51, Issue1, 37-53.

24. Yong, R. N. & Ouhadi, V. R. (2007). Experiment study on instability of bases on natural and Lime/cement-stabilized clayed soils. Applied Clay Science, Volume 26, Issues 3-4, 238-249.

Performance Evaluation of Cement-Stabilized Soft Clay Admixed with Coal Bottom Ash

*Zubbair, M. A.[1], Adejumo, T. E.[1], Amadi, A. A.[1] & Shehu, M.[1]
[1]Civil Engineering Department, Federal University of Technology, Minna Niger State, Nigeria
*Corresponding author email: mukhtarayomidezubbair@gmail.com (+2348034379758)

Abstract:

This research investigated the effect of adding cement and coal bottom ash at varying percentage on the consistency limits, compaction characteristics, unconfined compressive strength and CBR of the soil sample. Soil sample was collected from a borrow pit at depths of 1.5m and 2m. Index properties tests were conducted on the soft clay sample and classified under A-7-6, CL according to America Association of State Highways and Transportation Officer (AASHTO) and Unified Soil Classification System (UCSC) respectively. Result of the analysis revealed that the Liquid Limit increased with increasing cement and coal bottom ash content and Plasticity Index reduced with increasing percentage of cement and CBA. Plastic Limit increased from 25.32% for natural soil to 40.66% at 3:6% cement and CBA content and then returned to 0% at 6:9%, 9:12% and 12:15%. However, it was observed that Increasing cement and coal bottom ash content from 0 – 12:15% in the stabilized soil mixtures indicates a progressive increment in the MDD values for BSL, WAS and BSH. BSH gave the highest values of MDD which ranges between 1.77 – 1.83 g/cm³ and corresponding OMC values between 16.00 – 21.50% for mixtures tested. However, for BSL and BSH compaction cement and coal bottom ash content at 3:6% gives the highest MDD at the respective energy level. Addition of cement and coal bottom ash to the natural soil shows improvement in the UCS values of the stabilized specimen. BSH gave the highest value of 5871.92kN/m² for UCS at 28 days of curing.

Keywords: California bearing ratio, Coal bottom ash, soft clay, Stabilization, Unconfined compressive strength.

1.0 Introduction

Soft clay soils are recent alluvial deposits presumably formed through the most recent 10,000 years described by their featureless and flat ground surface. (Hussein *et al*., 2015) identified such clays by their low undrained shear strength (Cu<40 kPa) and high compressibility (Cc 0.19 to 0.44). These soils are found at high natural moisture content (typically ranging from 40-60%) with plasticity index ranging from 45-65% (Broms, 2017). Soils with such characteristics create serious problems to geotechnical engineering associated with stability and settlements problems (Abbawi, 2011). A soft sub grade in construction of roadways is one of the most frequent problems for highway construction in many parts of the world (Broms, 2017)

Soil stabilization, soil re-engineering or ground improvement is the process of altering or improving the one or more properties of weak or problematic soil in order to improve its performance under engineering load (Afrin, 2017; Zaliha *et al*., 2013). However, the choice of soil stabilization agents and soil stabilization technique is largely dependent on the index properties of the soil (EuroSoilStab, 2002). Lime, fly ash, Portland cement, blast furnace slags, rice husk, banana leave ash, bitumen or tar, polymers, fiber reinforcement, solid waste, organic matter, etc. have recorded some success to have been used as soil stabilizer over the year by researchers and engineers (Zumrawi and Hamza, 2012; Makusa, 2012; Abdullah *et al*., 2015; Ayyappan *et al*.2017; Afrin, 2017). Little has been done on the use of coal bottom ash as a soil stabilizer, although coal bottom ash has found applications in concrete production as partial replacement of sand and cement and as a pozzolan.

Coal bottom ash, a byproduct of coal combustion and a waste product of the locomotive system of train in rail transportation has found application as in concrete production as partial replacement of sand (Singha and Siddiqueb, 2013) as partial replacement of Portland cement (Kurama and Kaya, 2008) and as pozzolan (Jaturapitakkul and Cheerarot, 2003). This study intends to investigate the use of coal bottom ash in soil stabilization. The use of coal bottom ash will help create a synergy between Nigerian rail transportation, which is undergoing resuscitation, and its failing road transportation.

2.0 Materials and Methods

2.1 Materials

2.1.1 Soft Clay

The soft clay sample was collected from a borrow pit around Lapai-Gwari village, Chanchaga Local Government Area, Niger State. It was collected by method of disturbed sampling in conformity with BS 1377 (1992) at depths of 1.5 m to 2.0 m below the ground surface to avoid organic matter. The sample was then wrapped in polythene bags to avoid loss of moisture and transported to the Civil Engineering Laboratory, Federal University of Technology, Minna.

2.1.2 Coal bottom ash

The coal bottom ash used for the purpose of this study was obtained from a supplier in Kogi State.

2.1.3 Ordinary Portland Cement (OPC)

Dangote cement brand of grade 32.5 was used as the main binder because it is in conformity with BS EN 197-1:2000.

2.1.4 Water

The water used for this study is clean and portable, in accordance with BS EN 1008:2002.

2.2 Soil Sample Preparation

The physical properties of Coal bottom and Cement used were different, adding the additives is to identify the effect of constituents, changes that occur in the soil properties texture and water content of the sample. It was dried in the open air, and grinded into fine particles, and was made to pass through the B.S sieves.

2.3 Methods

2.3.1 Determination of Engineering Properties of collected sample

To determine the effect of stabilizers on soft clay sample, tests were carried out on the soft clay in accordance to BS 1377. Sieve analysis, Compaction, Atterberg limit test, California bearing ratio (unsoaked) and Unconfined compressive strength test was carried out.

2.3.2 Laboratory Experiments on Soft Clay

The laboratory experiments were conducted in accordance with B.S 1377 (1990). The engineering properties of the soil were determined using percentage of admixtures ranging from 3:6%; 6:9%; 9:12% and 12:15% respectively.

3.0 Results and Discussion

3.1 Index Properties of Soft Clay

The results of the preliminary tests conducted for identification and the determination of the properties of the natural soil are presented in Table 1 while the particle size distribution curve is shown in Figure 1. The soil is classified by AASHTO as A-7-6 and CL in the unified soil classification system (USCS) is reddish in colour and its geotechnical properties falls below the standard recommended for most civil engineering construction works especially highway construction (Osinubi and Medubi, 1997).

Table 1: Index Properties of Natural Soft Clay

Property	Value
% Passing BS sieve No. 200	82.20%
Specific Gravity	2.46

Liquid Limit	46%
Plastic Limit	25.32%
Plasticity Index	20.68%
AASHTO Classification	A-7-6
USCS classification	CL
Colour	Reddish

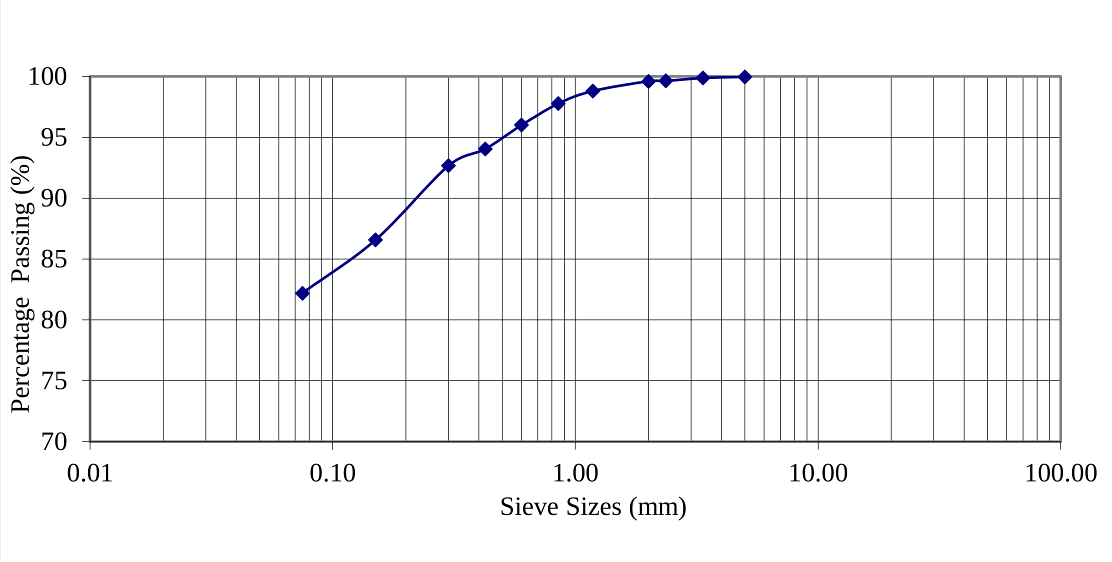


Figure 1: Particle size distribution curve of the Natural soft clay

3.2 Consistency Limits

Figure 2 shows the result of consistency limits of the natural soil and stabilized soil specimens using cement and coal bottom ash at 3:6%; 6:9%; 9:12% and 12:15%. Liquid limit of the natural soil increased from 46% to 82% upon adding 12:15% cement/coal bottom ash to the natural soil specimen. The Plastic Limit increased from 25.32% for the natural soil to 40.66% at 3:6% cement/coal bottom ash content before dropping to 0% at 6:9%, 9:12% and 12:15%. The Plasticity Index reduced significantly from 25.32% to 0% in the same sequence of cement and coal bottom ash treatment. Cement and coal bottom ash increased the compressibility and shrinkage/swelling potential of the soil due to the progressive increase in its liquid limit as well as shear strength as plastic index decreased with increasing cement/coal bottom ash content. The improved natural soil sample however, failed to meet Liquid Limit requirements for subgrade materials which is specified as; LL $\leq$ 35 but the Plastic Limit specification was met at PI $\leq$ 13% according to Federal Ministry of Works and Housing (1997).

According to Monther *et.al.* (1997), the Liquid Limit for clay decreased from 125 to 100% when coal bottom ash was used to stabilize it at varying percentages. Then, failure of mixtures to meet the required threshold values for liquid limit parameters suggests that lower cement content may be needed to achieve the specification requirements.

3.3 Strength Tests

3.3.1 Compaction

Figure 3 show how the Maximum Dry Density changes with the addition of cement and coal bottom ash for BSL, WAS and BSH Energy levels compaction. The MDD ranged from 1.56g/cm³ to 1.62g/cm³ for BSL, from 1.67g/cm³ to 1.77g/cm³ for WAS and from 1.77 g/cm³ to 1.83g/cm³ for BSH compaction as the cement and coal bottom ash content increased from 0 – 12:15%. Generally, the density of the soil increases with increasing cement/coal bottom ash content. British Standard Heavy which has the highest energy level of the three compacting efforts gave highest set of results, having MDD values ranging from 1.77 – 1.83g/cm³. The increase in MDD values suggest that increase in cement and coal bottom ash content has positive influence on the strength and density characteristics of the natural soil sample.

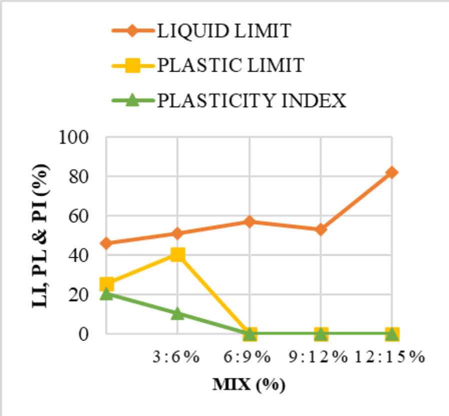


Figure 2: Variation of Atterberg limits value with %Cement and %Coal Bottom Ash

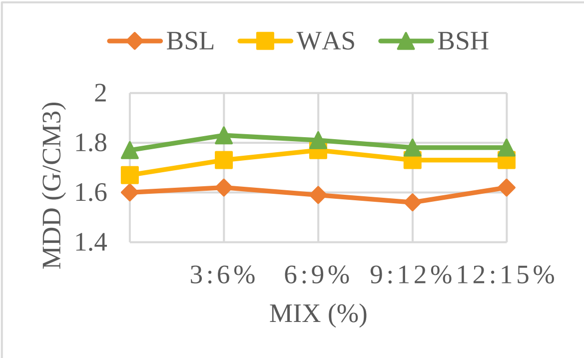


Figure 3: MDD with %Cement and %Coal Bottom Ash

Figure 4 shows how the optimum moisture content changes with the addition of cement and coal bottom ash for BSL, WAS and BSH compaction. In general, the OMC ranged from 20.30 – 25.50% for BSL, 17.40 – 23.20% for WAS and 16.00 – 21.50% for BSH as the cement/coal bottom ash content increased from 0 – 12:15%. The moisture range for the British Standard Heavy compaction was the lowest. In general, at higher compacting effort, higher MDD is attained at reduced OMC due to increase in the energy level and the rapid expulsion of voids in soil samples. The moisture contents at this energy level for the improved soil meet the requirement for subgrade material which is specified at w (%) < 18% according to Federal Ministry of Works and Housing (1997).

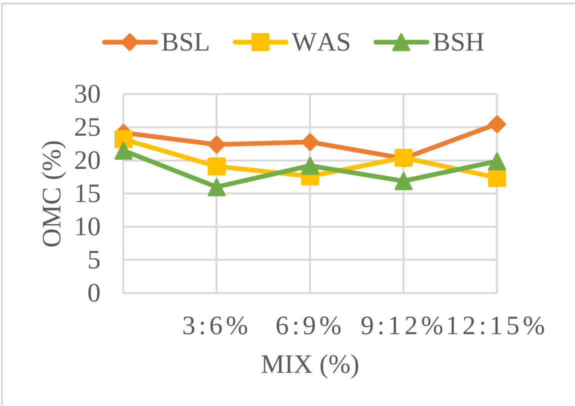


Figure 4: OMC with %Cement and %Coal Bottom Ash

3.3.2 California Bearing Ratio (CBR)

CBR is used to evaluate the strength property of subgrade soil in road construction. Unsoaked conditions were tested for the three compaction energy levels adopted in this research with cement and coal bottom ash content ranging from 0 – 12:15%. Figure 5 present the unsoaked CBR result which shows progressive increment in CBR value of the stabilized soil. Therefore, the results for WAS and BSH compaction satisfy the minimum requirement of 30% for unsoaked CBR when used as subgrade in flexible pavement construction according to Federal Ministry of Works and Housing (1997). The CBR results obtained shows that cement and coal bottom ash has significantly increased the strength properties of the natural soil when stabilized with cement/coal bottom ash for unsoaked CBR. Therefore, the load bearing capacity of the natural soil improves with the stabilization mix. The progressive increase in the California Bearing Ratio (CBR) for unsoaked condition with increasing cement/coal bottom ash content is an indication of the strength and stiffness of the soil-cement/coal bottom ash mixture. Also, WAS compaction gave then highest CBR value at 12:15% cement and coal bottom ash content.

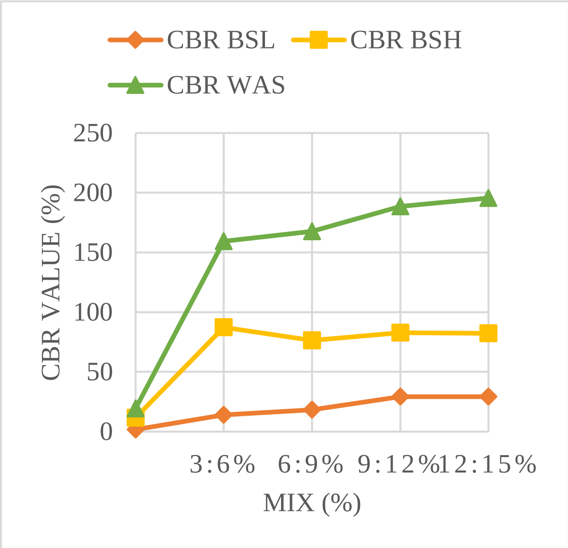


Figure 5: CBR value with %Cement and %Coal Bottom Ash

3.3.3 Unconfined Compressive Strength (UCS)

Figure 6 present the effect of cement and coal bottom ash on the Unconfined Compressive Strength (UCS) of the soil sample at 0 day for the three energy levels; BSL, WAS and BSH. The highest strength (563.11 kN/m^2 and 125.74 kN/m^2) for BSL and WAS compaction respectively was obtained at 6:9% cement and coal bottom ash content and 1318.62 kN/m^2 at 9:12% for BSH compaction was the highest strength of the three energy levels. Figure 7 present the effect of cement and coal bottom ash on the Unconfined Compressive Strength of the soil sample at 7 days of curing for the three energy levels. Generally, the strength of the soil sample improved gradually as the content of cement and coal bottom ash increased. Values obtained for BSH compaction were the highest of all the mixes at 7 days of curing from 188.94 kN/mm^2 for natural soil to 3648.41 kN/m^2 at 12:15% addition of cement/coal bottom ash. The trend at 7 days of curing repeated itself for curing at 28 days. The UCS values at 28 days are presented in Figure 8. Results of UCS obtained for the three-energy used indicate that higher compaction effort gave higher UCS value. Results of UCS for the three energy levels validate the potential of using cement and coal bottom ash to improve the strength parameters of subgrade.

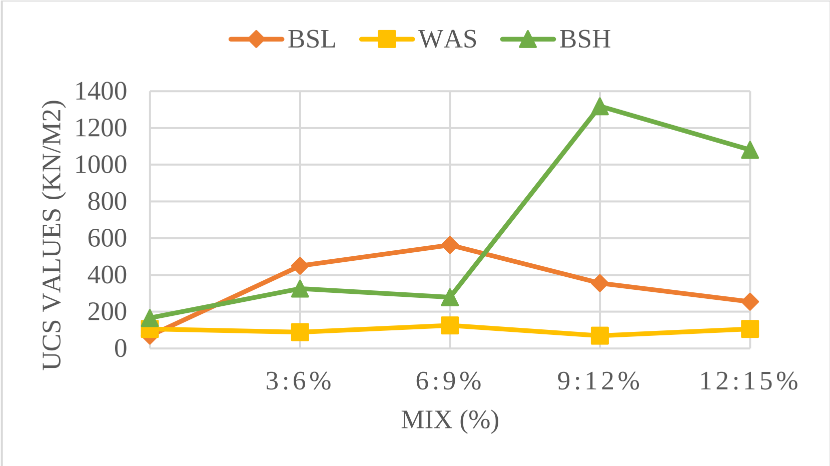


Figure 6: UCS with %Cement and %Coal Bottom Ash at 0 Day Curing

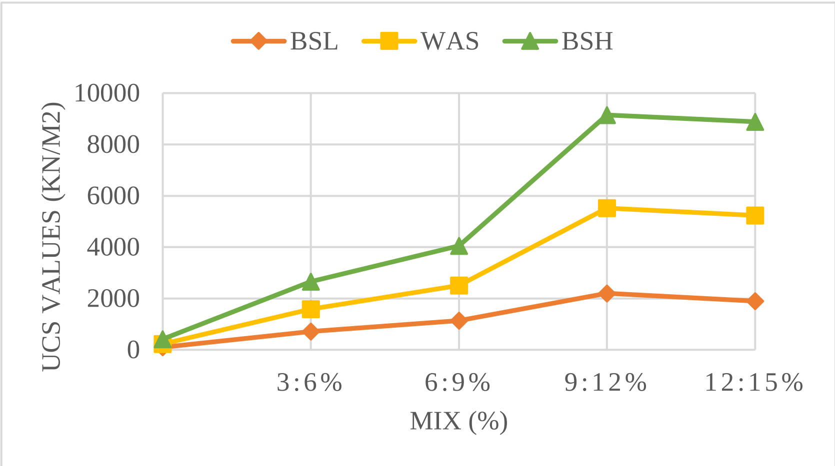


Figure 7: UCS with %Cement and %Coal Bottom Ash at 7 Days Curing

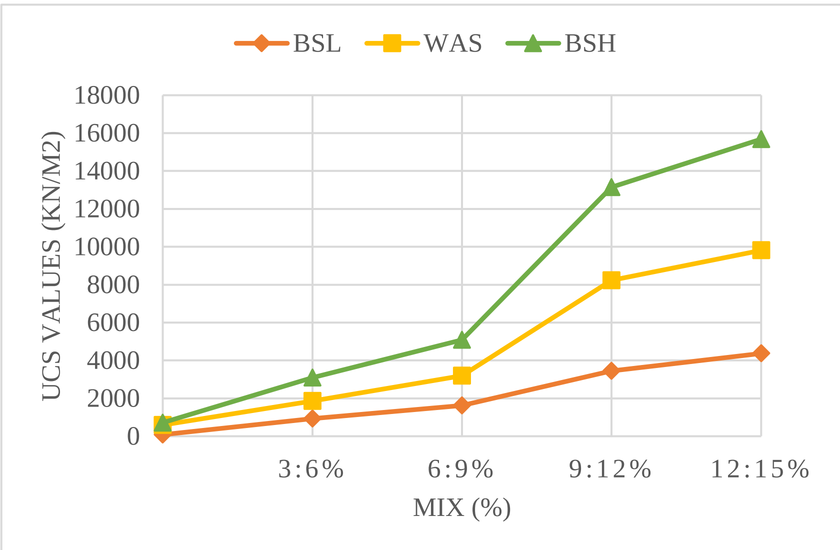


Figure 8: UCS with %Cement and %Coal Bottom Ash at 28 Days Curing

4.0 Conclusion

The research investigated the effect of adding up to 12:15% cement and coal bottom ash on the consistency limits, compaction characteristics, unconfined compressive strength and CBR soft clay. The following conclusions were drawn from the study;

- The natural soil is classified as A-7-6 according to AASHTO classification system and CL under Unified Classification System. The Liquid Limit increased with increasing cement and coal bottom ash content and Plasticity Index reduced with increasing percentage of cement and coal bottom ash. Plastic Limit increased from 25.32% for natural soil to 40.66% at 3:6% cement and coal bottom ash content and then returned to 0% at 6:9%, 9:12% and 12:15%.
- Addition of cement and coal bottom ash to the soil increased its swelling and shrinkage potential as liquid limit increased with increasing cement and coal bottom ash content as well as shear strength as plasticity index reduced with increasing cement and coal bottom ash content.
- Increasing cement and coal bottom ash content from 0 – 12:15% in the stabilized soil mixtures indicates a progressive increment in the MDD values for BSL, WAS and BSH. BSH gave the highest values of MDD which ranges between 1.77 – 1.83 g/cm³ and corresponding OMC values between 16.00 – 21.50% for mixtures tested. However, for BSL and BSH compaction cement and coal bottom ash content at 3:6% gives the highest MDD at the respective energy level; WAS compaction highest MDD is achieved at 6:9%. Generally, the Maximum Dry Density (MDD) shows an increase with increasing compaction effort.
- Addition of cement and coal bottom ash to the natural soil shows improvement in the UCS values of the stabilized specimen. BSH gave the highest value of 5871.92 kN/m² for UCS at 28 days of curing. Therefore, addition of cement and coal bottom ash to the natural soil improves strength significantly for BSH and WAS compaction.
- Generally, addition of cement and coal bottom ash to the natural soil improved CBR values for unsoaked conditions based on the three compaction energy levels adopted in this research. Therefore, addition of cement and coal bottom ash to the natural soil significantly improved the stabilized soil load bearing capacity. This shows that cement and coal bottom ash has positive influence on the soil strength properties.
- This research work therefore established the potentials of using cement and coal bottom ash to improve the consistency limits, moisture – density properties and strength properties of A-7-6 soil for use in road pavement subgrade.

REFERENCES

Abbawi, Z. (2011). Proposed Techniques for improving soft soil underneath a Ballasted Track.

Abdullah, M. S., Abdullah, M. M. and Ahmed, F. (2015). Geopolymer Application in Soil: A Short Review. 378-381.

Afrin, H. (2017). A Review on Different Types Soil Stabilization Techniques. *International Journal of Transportation Engineering and Technology*, 19-24.

Ayyappan, A., Palamikumar, S., Kumar, D. D. and Vinoth, M. (2017). Influence of Geopolymers in Stabilization of Clay Soil. . *International Journal of Emerging Technologies in Engineering Research (IJETER)*, 108-120.

Broms, B. B. (2017). Stabilization of Soft Clay in Southeast Asia. *5th International Geotechnical Seminar*, (pp. 2-4).

EuroSoilStab. (2002). Development of Design and Construction Methods to Stabilize Soft Organic Soils: Design Guide for soft soil stabilization *CT97-0351*. European Commission.

Federal Ministry of Works and Housing. (1997). Nigeria General Specifications for Roads and Bridges Volume 2.

Hussein, H. K, Zeena, W. S, & Salsabeel, F. A. (2015). Geotechnical Properties of Soft Clay Soil Stabilized by Reed Ashes. *2nd Int. Conf. on Buildings, Construction and Environmental Engineering.* Iraq.

Jaturapitakkul, C. and Cheerarot, R. (2003). Development of Bottom Ash as Pozzolanic Material. *Journal of Material and Civil Engineering*, 48-53.

Kurama, H and Kaya. (2008). Usage of Coal Combustion Bottom ash in concrete mixture. *Elsevier*, 1922–1928.

Makusa, G. P. (2012). Soil Stabilization Methods and Materials in Engineering Practice. Lulea, Sweden: Lulea University of Technology.

Monther Abdelhadi and Keinosuke Gotoh (1997). The Effect of Coal Ash on the Strength Parameters of Clay. *Reports of the Faculty of Engineering, Nagasaki University*, Vol. 28, No. 50, pp. 67.

Osinubi, K. J. and Medubi, A. B. (1997). Evaluation of Cement and Phosphatic Waste Admixture on Tropical Black Clay Road Foundation, *Proceedings of 4th International Conference on Structural Engineering Analysis and Modeling (SEAM 4)*, Kumasi, Ghana, Vol. 2, pp. 297-307.

Singha, M & Siddiqueb, R. (2013). Effect of Coal Bottom Ash as Partial Replacement of Sand on Properties of Concrete. *Elsavier*, 20-32.

Zaliha, S. Z., Kamarudin, H., Al Bakri, A. M. & Salwa, M. S. (2013). Review on Soil Stabilization Techniques. *Australian Journal of Basic and Applied Sciences*, 258-265.

Zumrawi, M. E. & Hamza, S. M. (2012). Improving the Characteristics of Expansive Subgrade Soils Using Lime and Fly Ash. *International Journal of Science and Research (IJSR)*, 1124-1129.

Beneficiation and Characterisation of Kaolin Clay from Clay Deposit in Kutigi, Niger State, Nigeria

Ogundipe F.O[1a]., Saidu M[2b]., Abdulkareem, A.S.[3c]. & Busari, A.O[2d].
[1]*Federal Ministry of Water Resources, Abuja, Nigeria*
[2]*Deaprtment of Civil Engineering, Federal University of Technology, Minna, Nigeria*
[3]*Department of Chemical Engineering, Federal University of Technology, Minna, Nigeria*
[a]ogundipefelixo@yahoo.com; [b]m.saidu@futminna.edu.ng; [c]kasaka2003@futminna.edu.ng; [d]busari.a@futminna.edu.ng
Corresponding author: ogundipefelixo@yahoo.com

Abstract

Kaolin is widespread across Niger State in Nigeria, relatively free of charge, non-toxic and environmentally friendly. In this study, kaolin clay from Kutigi, Niger State, Nigeria was beneficiated and characterised for their crystal structure and morphology using X-Ray Diffractometer (XRD), Dispersive X – Ray Fluorescence (XRF) Machine, High Resolution Transmission Electron Microscope (HRTEM) and Brunauer – Emmett – Teller (BET) Nitrogen Absorption Analyser. The average crystallite size of the raw kaolin and Beneficiated Kaolin Clay (BKC) was calculated to be 40.258nm and ***28.114nm*** *respectively. The XRD analysis showed that the BKC had four (4) different phases of kaolinite: $Al(Si_2O_5)(OH)_4$, kaolinite 1Md – $AlSi_2O_5(OH)_4$, quartz – SiO_2 and muscovite – $KAl_2(Si_3Al)O_{10}(OH)_2$. XRF analysis showed a SiO_2/Al_2O_3 ratio of 1.54 and 1.35 in raw and BKC respectively. The Selected Area Electron Diffraction (SAED) pattern showed that the raw clay and BKC were polycrystalline in nature with each bright spots reflecting individual peaks. The Bet analyses showed that the adsorption-desorption isotherms for the BKC possessed pore size of mesopore widths between 13.8994 nm, surface area of 14.5126 m^2g^{-1}, pore volume of 0.003740 cm^3/g and adsorption average diameter of 1.0309 nm. This research work showed that kaolin clay from Kutigi is poly-crystallinity in nature and could be used as adsorbent for wastewater treatment.*

Keywords: Beneficiation, Kaolin, Clay, Kutigi, Nigeria.

Introduction

Human society has been using clays and clay minerals since the stone age, primarily since clay minerals are common at the earth's surface and are widely utilized for agriculture (soils), ceramics and building materials with a very long history (Auta and Hameed, 2013; Murray, 2000; Saikia *et al*, 2003; Chun et al, 2013), Clay is used by engineering geologists and sedimentologists to describe geological materials of less than 4 µm in size, by soil scientists to denote the soil fraction containing particles of less than 2 µm size, and colloidal scientists of less than 1 µm (Chun *et al*, 2013). Clay materials are cheaper than activated carbons and their sheet-like structures also provide high specific surface area (Dhaval & Painter, 2017). The inherent features of clay minerals that make them attractive for use in a wide variety of applications include very large surface area that arises from the layered structure, along with its swell ability and the potential for delamination; small size of the particles in the range of micro- to nanoscale; and naturally charged particles leading to relatively strong electrostatic interactions (Chun *et al*, 2013). Pure kaolinite is white in colour and its chemical composition is 46.54% SiO_2, 39.50% Al_2O_3 and 13.96% H_2O and presence of impurities, particularly iron and titanium bearing materials, imparts colour to kaolin (Saikia *et al*, 2003). The mined kaolin is usually associated with various impurities like quartz, anatase, rutile, pyrite, siderite and feldspar depending on the origin and depositional environment. Clay materials can be modified using a variety of chemical/physical treatments to achieve the desired surface properties for best immobilization of contaminants (Aroke and Onatola, 2016). Physical and chemical behaviours of clay minerals have been studied by numerous researchers due to their adsorbing and catalytic properties (Sachin *et al*, 2013). The three main groups of clay minerals are kaolinite, montmorillonite or smectite and illite. Kaolin is another aluminosilicate mineral which is found among different type of clays (Kuranga *et al* 2018; Karl *et al*, 1996; Yahaya *et al*, 2017). Kaolin is widespread across Niger State, relatively free of charge, non-toxic and environmentally friendly. Niger State produced a total of 51,149.80 tons of solid minerals in 2016 (RMRDC, 2012).

Materials and Methods

The kaolin clay sample was collected from a clay deposit in Kutigi in 20 kg capacity leather bag and transported to the National Water Quality Reference Laboratory Minna for further processing and analyses. Kutigi Town is located at longitude 9º 12' 0" N and latitude 5º 36' 0" E. Removal of leaves and dead insects was done, and the kaolin clay oven dried at 105ºC for 6 hours. The oven dried kaolin clay was crushed with a mortar and pestle, grinded to particle that could pass through a 250 µm mesh sieve to obtain very fine particles. The oven dried raw kaolin clay was processed by sedimentation technique to produce clay fractions of < 2 µm hydrodynamic diameter and removal of excess non-clay impurities. The kaolin clays were allowed to swell in distilled water for 22hrs 57mins to allow for proper intercalation of the clay structure by water molecules (Bachiri *et al*, 2014). The sedimentation of the slurries was monitored and done according to the Stoke's Law with the following formula:

$$u_s = \frac{g(\rho_p - \rho_w)d_p^2}{18\mu} \quad (1)$$

Where ρ_p = particle density, kg/m^3 (Kaolin clay particle = 1600kg/m^3); μ = liquid viscosity, kg/m.s (distilled water = 8.90 × 10^{-4} Pa·s); ρ_w = density of water, kg/m^3 (997kg/m^3); u_s = particle settling velocity, m/s; d_p = diameter of particle, m; g = acceleration due to gravity, m/s^2 (9.81m/s^2); t = Settling Time; R = particle size (radius) of clay, assumed to be spherical (1µm = 1 X 10^{-6}m); h = Settling Height of Fluid.

The beneficiated kaolin clay was activated with 0.5M HCl, washed with 10% Hydrogen Peroxide (H_2O_2) to oxide organic matter (Bachiri et al, 2014) and distilled water until the pH 7 was obtained. The Mass of the activated BKC obtained was measured and the value substituted in the following equation to obtain the percentage yield of the kaolin clay.

$$Y = \frac{Mass\ of\ Purified\ Kaolin\ Clay\ Produced}{Mass\ of\ Raw\ Kaolin\ Clay}\ x\ 100\ \% \quad (2)$$

The identification of phases and the crystallite sizes of the raw kaolin clay and BKC were determined using the Emma 0141 X-Ray Machine by GCB scientific Equipment. The phase identifications were done by comparison with available d-spacing information and peaks from International Centre for Diffraction Data (ICDD) and Powder Diffraction File (PDF). The interplanar spacing for diffraction angle of each peak (d-spacing) was calculated using Braggs law in the following equation. $n\lambda = 2d\sin\theta$; Where λ = wavelength of X-Ray = 1.5406 Å; d = d-spacing in Å, θ = Diffraction angle in radians. The unit cell parameters were calculated and indexed as *h k l*. Full Width at Half Maximum (FWHM) of the selected peak was determined using student version of OriginPro 2021b (trial) data and analysis software from OriginLab Corporation, Northampton, USA. The average crystallite size of the clay was calculated from the analysis of the peaks in the X-Ray diffractogram using the following Scherer Equation.

$$D = \frac{K\lambda}{\beta \cos\theta} \quad (3)$$

Where; λ = Wavelength of X-Ray, CuKa = 1.5406 Angstrom (À), K=Scherer Constant (0.94 for spherical crystallites with cubic symmetry), β = Full Width at Half Maximum (FWHM) for the peaks in radians, θ = Bragg's diffraction angle in degrees

TECNAI G2 F20 twin model High Resolution Transmission Electron Microscope (HRTEM) was used for the analysis of particle size and distribution pattern of the raw and BKC. The surface area and pore volume of the BKC was determined using the TriStar II 3020 BET Nitrogen adsorption technique. The chemical analysis of the generated BKC was done using Dispersive X – Ray Fluorescence (XRF) machine (EDXRF-3600B) by Oxford instrument. Loss on Ignition (LOI) test was conducted on the raw and purified kaolin clay to determine the mass of the volatile matters present in each sample tested.

Results And Discussion

The yield of kaolin clay fractions of less than 2 µm from the raw kaolin clay is presented in Table 1. The yield increased with increase in the percentage slurry from 2.5 %, w/w to 5 %, w/w and remained constant at 7.5 %, w/w and 10 %, w/w. The lower yield experienced at 7.5 and 10 %, w/w slurry could be attributed to the repulsion forces between the negatively charged clay particles which were free in the suspension and hence prevented particles from settling at the experimental calculated time of 22hrs 57mins (Table 2) for particles of less than 2 µm.

Table 67: Yield of Beneficiated Kaolin Clay

Kaolin Clay Slurry	Dried Mass of Raw Sample (g)	Dried Mass of Beneficiated Kaolin Clay (g)	Yield (%)	Settling Height (cm)
2.5 %, w/w	100	7.60	7.60	8.10
5.0 %, w/w	200	18.3	9.15	12.0
7.5 %, w/w	300	27.4	9.13	9.20
10 %, w/w	400	36.5	9.13	9.20

The kaolin clay slurries during the sedimentation technique were allowed to settle according to Stoke's Law and the settling time result along with the other design parameters for purification of the kaolin clay are presented in Table 2. The soil particles are denser than water, they tend to sink, settling at a velocity that is proportional to their size. The speed at which the kaolin particles settled during the purification process was 1.477 X 10^{-6} m/s. The settling time was calculated to be 22hrs 57mins.

Table 68: Kaolin Clay Sedimentation Design Parameters

Parameters	Results	Remarks
Liquid Viscosity, kg/m.s	8.90×10^{-4} kg/m.s	Viscosity of Distilled Water
Kaolin Clay Particle Density, kg/m^3	1600kg/m^3	Particle Density
Density of Water, kg/m^3	997kg/m^3	Density of Water
Acceleration due to Gravity, m/s^2	9.81m/s^2	Gravitational Force
particle size (radius) of kaolin clay, m	1μm = 1 X 10^{-6}m	assumed to be spherical
Settling Height, m	0.12m	Measurement of the Supernatant
Kaolin clay Settling Velocity, m/s	1.477 X 10^{-6}m/s	Calculated using Stoke's Law
Kaolin Clay Settling Time, hrs	22hrs 57mins	Calculated using Stoke's Law

The physicochemical properties of the raw and beneficiated kaolin were presented in Table 3. The pH values of the raw and beneficiated clay were 5.60 and 7.02 respectively. The pH value of the beneficiated clay is slight neutral and will promote pollutants precipitation and adsorption. The organic matter in the raw kaolin clay could be attributed to the presence of dead animals and insects. The cation exchange capacity (CEC) of the raw kaolin clay and beneficiated clay were 8.65 and 12.5 meq/100g. The CEC characteristic would make the beneficiated kaolin clay play an important role in the adsorption of metal ions. The Electrical Conductivity (EC) of the beneficiated clay was higher than that of the raw kaolin clay. The higher EC in the beneficiated kaolin showed that it contained dissolved salts that could allow for the removal of phosphate, nitrate and some toxic metal ions in the domestic wastewater.

Table 69: Selected Physicochemical Properties of Raw and Beneficiated Kaolin

Parameters	Raw Kaolin Clay	Beneficiated Clay
Colour	Off White	White
Particle Shape	Spherical	Spherical
Texture	Coarse	Fine
pH	5.60	7.02
Organic Carbon, %	0.045	0.00
Cation Exchange Capacity (CEC), meq/100g	8.65	12.5
Electrical Conductivity, μS/cm	245	297
Density, g/cm3	2.70	2.60
Viscosity (cP)	6.69	6.89

XRD diffractograms of raw kaolin clay and BKC displayed the existence of four crystalline phases of kaolinite – $Al(Si_2O_5)(OH)_4$, kaolinite 1Md – $AlSi_2O_5(OH)_4$, quartz – SiO_2 and muscovite – $KAl_2(Si_3Al)O_{10}(OH)_2$. These four identified phases were chemically identical, but their atoms were arranged differently except that of muscovite that contained potassium (Tables 4 and 6). The dominated impurity coumpound in the raw kaolin clay and BKC was quartz with 66.41 % and 46.85% respectively. Multiple peaks were detected for each phase between 5.077° to 85.049°. The best peaks produced at the Full Width at Half Maximum (FWHM) of the intense peak for raw kaolin clay and BKC ranged from 0.1588 – 0.40475 radians and 0.1825 – 0.5118 radians respectively. The broad peaks formation of the XRD pattern for both raw kaolin clay and PKC showed that they were both polycrystalline in nature. The XRD pattern showing various peaks produced in the characterisation of raw kaolin clay and BKC is presented in Figure 1. Interplanar spacing between the parallel planes of atoms in raw kaolin clay and BKC were 3.4994 nm and 3.532nm at Scherrer's constant of 0.94 and wavelength (λ) of 1.5406 Å. The average crystallite size for the raw kaolin clay and BKC were calculated to be 40.258nm and 28.114nm as shown in Tables 5 and 7.

Table 70: XRD Phase Identification of Raw Kaolin Clay

Phases	Formula	Percentage (%)
Kaolinite	$Al(Si_2O_5)(OH)_4$	14.10
Kaolinite 1Md	$AlSi_2O_5(OH)_4$	15.04
Quartz	SiO_2	66.41
Muscovite	$Kal_2(Si_3Al)O_{10}(OH)_2$	4.45

The average crystallize size (28.114nm) of beneficiated kaolin clay were less than that of raw kaolin clay (40.258nm). The lower the crystallize size the higher the surface area. This implied that the beneficiated clay would be more potent in the contaminant's removal from domestic wastewater than the raw kaolin clay. The crystallite size is an important parameter as the sizes of the crystals determine whether the material is soft (small crystallites) or brittle (large crystallites), as well as thermal and diffusion behaviour of semicrystalline polymers (Sanjeeva, 2013).

Table 71: Interplanar Spacing and Crystallite Size of Raw Kaolin Clay

Diffraction Angle, 2θ	d- spacing, (nm)	FWHM of the Intense Peak, β, (radians)	Crystallite Size, D, (nm)
12.2860	7.2203	0.25190	33.129
24.8213	3.5950	0.32526	26.120
26.5769	3.3613	0.15880	53.688
50.0630	1.8258	0.14218	64.408
62.2406	1.4945	0.40475	23.946
Average	3.4994		40.258

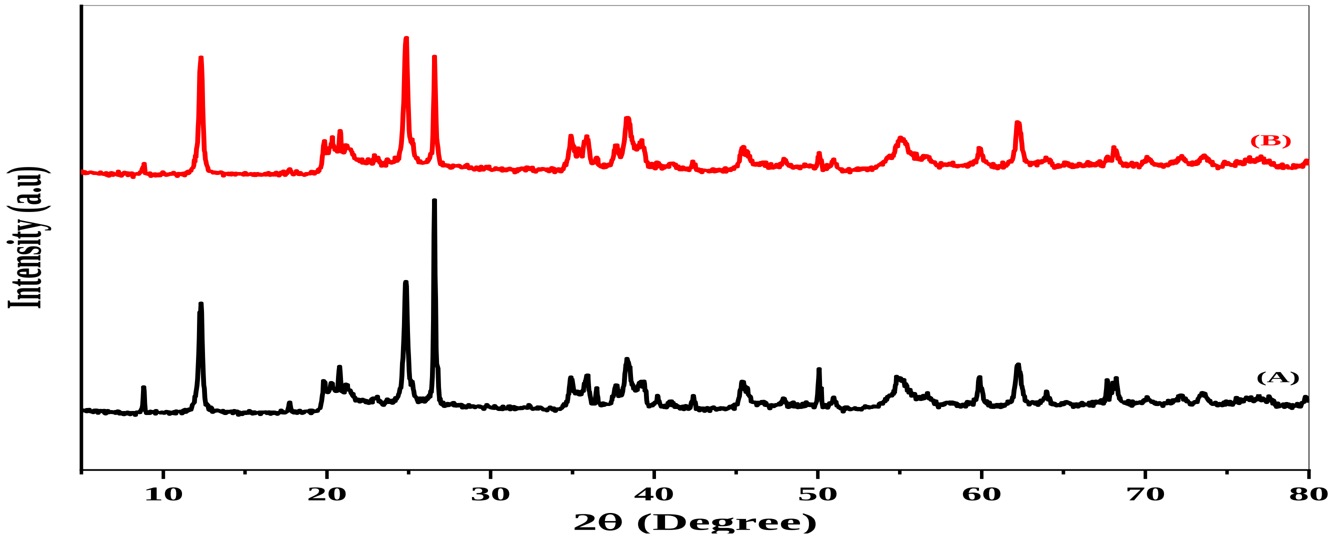


Figure 11: XRD patterns of (A) Raw kaolin and (B) beneficiated kaolin

Table 72: XRD Phase Identification of Beneficiated Clay

Phases	Formula	Percentage
Kaolinite	$Al(Si_2O_5)(OH)_4$	28.52
Kaolinite 1Md	$AlSi_2O_5(OH)_4$	19.01
Quartz	SiO_2	46.85
Muscovite	$Kal_2 (Si_3Al)O_{10}(OH)_2$	5.62

Table 73: Interplanar Spacing and Crystallite Size of Beneficiated Clay

Diffraction Angle, 2θ	d- spacing, (nm)	FWHM of the Intense Peak, β, (radians)	Crystallite Size, D, (nm)
12.2966	7.2142	0.3106	26.869
24.8279	3.5940	0.3225	26.348
26.5858	3.3602	0.1825	46.714
45.5049	1.9975	0.5118	17.580
62.2534	1.4942	0.4203	23.060
Average	3.532		28.114

Table 8 shows the results of chemical analysis of the raw and beneficiated kaolin clay. The raw kaolin clay contained alumina (34.18%) and silica (52.64%) in large quantities. The beneficiated kaolin clay contained alumina of 35.95 % and silica of 48.55% respectively. The proximity of silicate and alumina compositions obtained in the raw and beneficiated kaolin showed that raw kaolin has silicate more than beneficiated kaolin clay and the beneficiated kaolin clay contained alumina more than the raw kaolin. The loss of silicate and the gain of alumina in the beneficiated kaolin clay could be attributed to the purification and treatment method employed for the beneficiation of the kaolin clay. The SiO_2/Al_2O_3 ratio of kaolin clay which is a function of the mineral phase present was found to be 1.54 and 1.35 in raw and beneficiated kaolin clay respectively. Clay minerals are classified by the ratio of their silica and alumina sheets. The SiO_2/Al_2O_3 ratio of beneficiated clay (1.35) as gotten in this study showed a purer kaolinite than the raw clay. Loss on ignition (LOI). LOI for raw and beneficiated kaolin were 8.90% and 11.62% respectively. The high LOI for beneficiated clay is attributed to the dehydroxylation reaction in the kaolin mineral. High LOI for beneficiated clay was also an indication of potential normal porosity in the intended kaolin clay filter adsorbent for treatment of domestic wastewater.

Table 74: Mineralogical composition (XRF) of Raw and Beneficiated Clay

Compound	Raw Kaolin Clay (%)	Beneficiated Kaolin Clay
Fe_2O_3 %	1.23	1.24
MnO %	0.00	0.00
Cr_2O_3 %	0.02	0.02
V_2O_5 %	0.00	0.00
TiO_2 %	1.69	1.75
CaO %	0.33	0.02
K_2O %	0.61	0.63
P_2O_5 %	0.07	0.05
SiO_2 %	52.64	48.55
Al_2O_3 %	34.18	35.95
MgO %	0.23	0.03
Na_2O %	0.11	0.14
LOI %	8.90	11.62
Total	100	100
SiO_2/Al_2O_3 Ratio	1.54	1.35

The crystal patterns of the raw kaolin clay are presented in Plate I (a – e). HRTEM of raw kaolin clay showed kaolinite particles of varying sizes arranged in face-to-face patterns. The crystallinity of the raw kaolin clay structure was examined using Selected Area Electron Diffraction (SAED) pattern in Plate I (f). The SAED pattern showed concentric circles of polycrystallinity. The bright spots and rings of the SAED pattern suggested that the raw kaolin clay is polycrystalline in nature and each ring depicted diffraction pattern of crystals of similar size with each bright spots reflecting individual peaks. SAED resolution pattern obtained were consistent with the results of XRD and XRF characterisation in this study. EDX analysis of the raw kaolin clay showed the presence of Oxygen, Aluminium and Silicon with minor amounts of Potassium, Titanium and Iron. The % atomic weight and % weight sigma of elements identified by the EDX analysis for raw and beneficiated kaolin clay is presented in Table 9. HRTEM images in Plate II (a – e) showed the structure of the beneficiated kaolin clay. HRTEM of beneficiated clay showed kaolinite particles of varying sizes arranged in face-to-face patterns. The crystal structure in Plate II (f) showed bright rings of the SAED patterns that are polycrystalline in nature. Each ring depicted the diffraction pattern of purified kaolin clay particles.

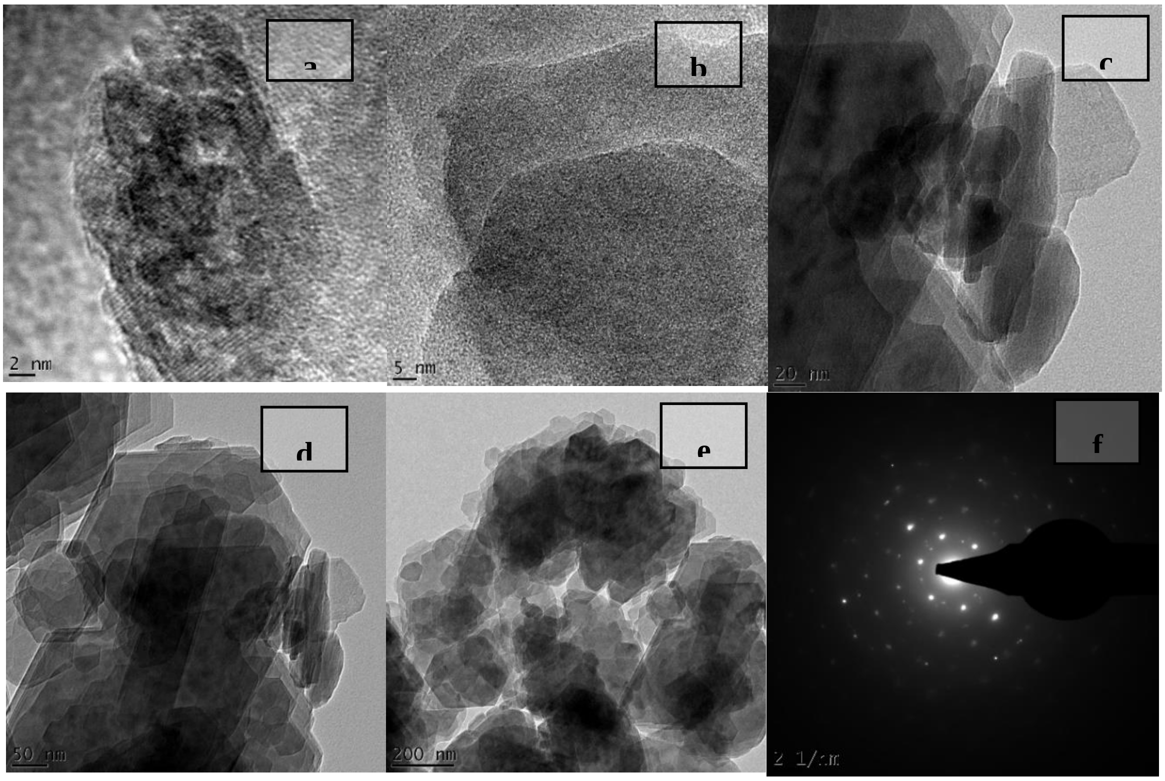


Figure 12: Plates showing HRTEM (a – e) and SAED (f) Images of Raw Kaolin Clay

Table 75: EDX Analysis of Raw Clay

Element	%weight	%weight Sigma
O	47.6	0.24
Al	22.7	0.15
Si	26.7	0.17
K	0.42	0.05
Ti	1.19	0.07
Fe	1.43	0.09
Total:	100	0.77

The EDX point micrograph showed the presence of Oxygen, Aluminium and Silicon with minor amounts of Potassium, Titanium and Iron. The % atomic weight and % weight sigma of elements identified by the EDX analysis for beneficiated kaolin clay is presented in Table 10. Although, the raw and the beneficiated kaolin clay exhibited similar morphologies based on EDX results, their elemental constituent differed. As it could be seen, the major difference may be attributed to the percentage reduction of iron, oxygen and aluminium and increase in presence of potassium, silicon and titanium in the beneficiated clay. These results suggested that there would be a possibility of cation exchange between the beneficiated kaolin clay and metal ions during treatments. This could enhance high adsorption capacity and improve removal efficiency of pollutants by the beneficiated kaolin clay. These results are consistent with the XRD and XRF results as earlier discussed.

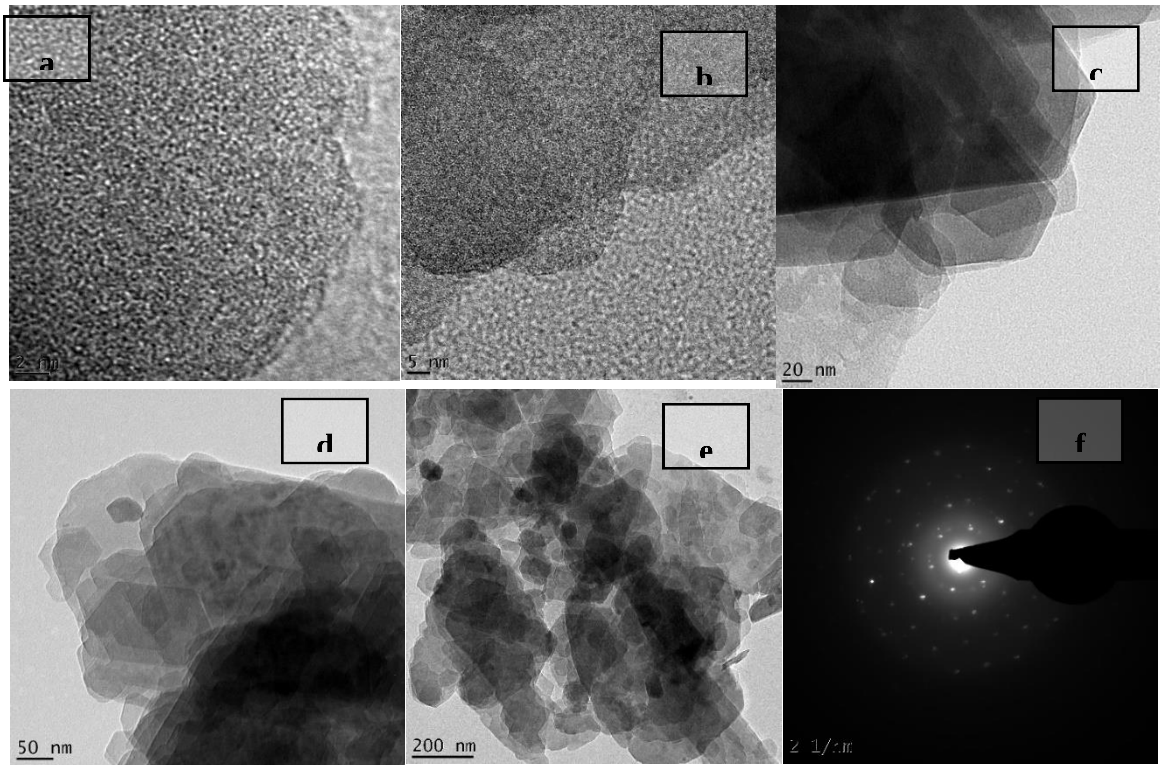
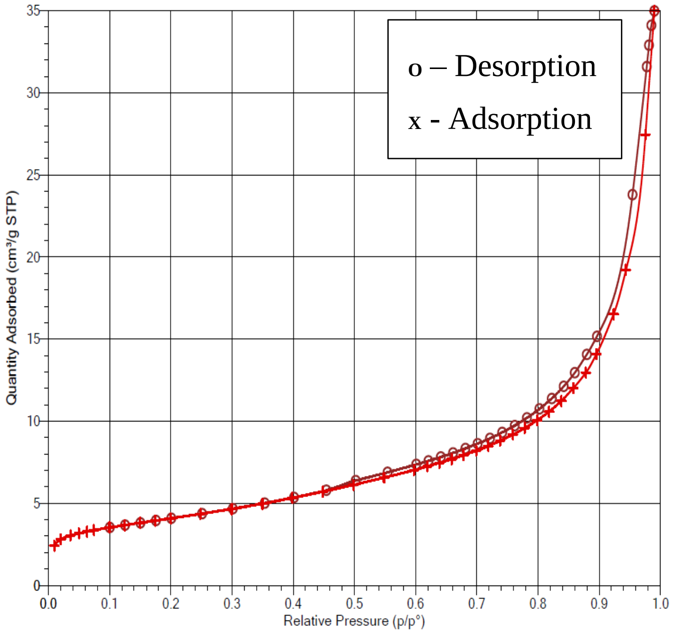


Figure 13: Plate showing HRTEM (a – e) and SAED (f) Images of Beneficiated Kaolin Clay

Table 76: EDX Analysis of Beneficiated Kaolin Clay

Element	%Weight	%Weight Sigma
O	46.92	0.26
Al	21.42	0.16
Si	28.34	0.19
K	0.53	0.05
Ti	1.48	0.08
Fe	1.30	0.10
Total:	100	0.84

Nitrogen (N_2) adsorption-desorption isotherm showed that the beneficiated kaolin clay belongs to type IV isotherm with a hysteresis loop (Figure 2), which resulted from capillary condensation in the mesopores (diameter, $2 < d < 50$ nm) at the relative pressure range of 0.45 –0.9, P/Po. When the relative pressure was 0.4 – 0.9 P/Po, the desorption branch was obviously higher than the adsorption branch, along with the appearance of capillary condensation, which resulted in the hysteresis loop. At the relative pressure of 0.4 – 0.9 P/Po, the adsorption branch and desorption branch suddenly rose and coincided at the end (Figure 2). Therefore, the occurrences of hysteresis loops indicated that the beneficiated kaolin clay had a lot of mesopores. The quasi-overlapping adsorption-desorption curves indicated that the N_2 adsorption-desorption isotherm curve of the beneficiated kaolin clay can be classified as Type IV, indicating a purely mesoporous material with small pore size. Furthermore, the IUPAC classified Hysteresis Loops into four types, each type representing a different pore shape (Xu *et al*, 2020). Accordingly, hysteresis loops of the beneficiated kaolin clay belong to type H3, demonstrating that wedge-shaped pores took the primary position in the beneficiated kaolin clay.



The adsorption-desorption isotherms for the beneficiated kaolin clay possessed pore sizes that fell in the BJH desorption average pore width of 13.0470nm (Table 13). The BET surface area of beneficiated kaolin clay was 14.5126 m^2g^{-1}, the single point adsorption total pore volume was 0.003740 cm^3/g, adsorption average diameter was 1.0309 nm and BJH adsorption average pore width was 13.8994nm. Strong adsorbents used for water treatment have large surface areas (Worch, 2012). The BET analysis results showed the beneficiated kaolin clay as promosing materials that could be used as adsorbent for filter production

Figure 14: BET Analysis of Beneficiated Kaolin

Conclusion

The beneficiation of Kutigi kaolin clay produced a crystallite size of 28.114nm. XRF analysis reflected a SiO_2/Al_2O_3 ratio of Kutigi kaolin clay and BKC to be 1.54 and 1.35 respectively. The crystal structure and morphology of BKC showed that kaolinite particles of varying sizes were arranged in face-to-face patterns with the bright spots and rings of the SAED pattern suggested that the raw clay and BKC were polycrystalline in nature. BET surface area for the BKC was determined to be 14.5126 $m^2.g^{-1}$, pore volume was 0.003740 cm^3/g and adsorption average diameter was 1.0309 nm. BJH adsorption average pore width was found to be 13.0470 nm.

Acknowledgement

OriginLab Corporation, Northampton, USA: Provision of Student version of OriginPro 2021b (trial) data and analysis software to calculate Full Width at Half Maximum (FWHM) of the selected peak. Federal Ministry of Water Resources Abuja, Nigeria: Free access to National Water Quality Reference Laboratory Minna. Nanotech Research Group, Federal University of Technology, Minna: Interfacing and liaising with the University of South Africa to characterize the kaolin clay and BKC samples.

References

Aroke U. O. and Onatola-Morakinyo S. (2016). Comparative Sorption of Diatomic Oxyanions onto HDTMA-Br Modified Kaolinite Clay. *International Journal of Engineering and Science* Vol.6, Issue 7 (August 2016), PP -01-09 Issn (e): 2278-4721, Issn (p):2319-6483, www.researchinventy.com

Auta M.and Hameed B.H.(2013). Acid modified local clay beads as effective low-cost adsorbent for dynamic adsorption of methylene blue. *Journal of Industrial and Engineering Chemistry*, 1153–1161, http://dx.doi.org/10.1016/j.jiec.2012.12.012

Bachiri El .M., Akichouh El Miz .H., Salhi S. and Tahani A. (2014). Adsorptions desorption and kinetics studies of Methylene Blue Dye on Na-bentonite from Aqueous Solution. *IOSR Journal of Applied Chemistry* (IOSR-JAC) e-ISSN: 2278-5736.Volume 7, Issue 7 Ver. III. (July. 2014), PP 60-78 www.iosrjournals.org

Chun Hui Zhou and John Keeling (2013). Fundamental and applied research on clay minerals: From climate and environment to nanotechnology. *Applied Clay Science* 74 (2013) 3–9. http://dx.doi.org/10.1016/j.clay.2013.02.013

Dhaval Patel and Z.Z.Painter (2017). Batch and Column Study for Treatment of Sugar Industry Effluent by using low-cost Adsorbent. Vol-3 Issue-3 2017 *IJARIIE*-ISSN(O)-2395-4396

Karl Terzaghi, Ralph B. Peck and Gholamreza Mersi (1996). Soil Mechanics in Engineering Practice. Third edition published by John Wiley and Sons Inc., New York, USA

Kuranga I.A, Alafara A.B, Halimah, Fb, Fausat A.M., mercy O.B. and Tripathy B.C. (2018). Production and Characterization of Water Treatment Coagulant from locally sourced Kaolin Clays. *J. Appl. Sci. Environ. Manage*. January, Vol. 22 (1) 103-109. DOI: https://dx.doi.org/10.4314/jasem.v22i1.19

Murray Haydn H. (2000). Traditional and new applications for kaolin, smectite, and palygorskite: a general overview. *Applied Clay Science* 17 _2000. 207–221

NBS. (2017). State Disaggregated Mining and Quarrying Data. *National Bureau of Statistics*, Nigeria.

RMRDC. (2018). National Distribution of Raw Materials – Niger State

Saikia N.J., Bharali D.J., Sengupta P., Bordoloi D., Goswamee R.L., Saikia P.C. and Borthakur P.C. (2003). Characterization, beneficiation and utilization of a kaolinite clay from Assam, India. *Applied Clay Science* 24 (2003) 93– 103. doi:10.1016/S0169-1317(03)00151-0

Sachin Kumar, Achyut Kumar Panda and R. K. Singh (2013). Preparation and Characterization of Acids and Alkali Treated Kaolin Clay. *Bulletin of Chemical Reaction Engineering and Catalysis*, 8 (1), 2013, 61 – 69, http://bcrec.undip.ac.id

Sanjeeva Murthy, N. (2013). Scattering techniques for structural analysis of biomaterials. *Characterization of Biomaterials, 34–72.* doi:10.1533/ 9780857093684.34 10.1533/9780857093684.34

Worch E. (2012). *Adsorption Technology in Water Treatment Fundamentals, Processes, and Modeling*. Walter de Gruyter GmbH and Co. KG, Berlin. 345pp.

Xu, L., Zhang, J., Ding, J., Liu, T., Shi, G., Li, X., … Guo, R. (2020). *Pore Structure and Fractal Characteristics of Different Shale Lithofacies in the Dalong Formation in the Western Area of the Lower Yangtze Platform. Minerals, 10(1), 72.* doi:10.3390/min10010072 10.3390/min10010072, downloaded on 20 – 12 - 2022

Yahaya Shehu, Suzi Salwah Jikan, Nur Azam Badarulzaman and Ajiya Dahiru Adamu (2017). Chemical Composition and Particle Size Analysis of Kaolin, *Path of Science*. Vol. 3, No 10 ISSN 2413-9009. DOI: 10.22178/pos.27-1

Factors Contributing to Stress Among Construction Practitioners in Kaduna

Yusuf, I.[1a] & Ola-Awo, A. W.[1b]
[1]Department of Quantity Surveying, Federal University of Technology, Minna, Nigeria
[a]yusibm10@gmail.com, [b]olaade4u2006@gmail.com [2]
Corresponding author: yusibm10@gmail.com; (08169655424, 08062382854)[2]

Abstract:

Stress at the workplace has become one of the main problems in the modern world and is one of the world's most common health concerns. Workplace stress affecting the success of construction firms because it affects the productivity and efficiency of employees. In view of this, the study factors contributing to stress among construction practitioners with a view to suggesting strategies for effective management of stress. This study was quantitatively conducted via questionnaire survey. The research instrument was administered to construction practitioners in the study area. The respondents were selected using simple random sampling technique. Data was analysed using descriptive statistic such as mean item score. The study identified the major three (3) most prevalent factors contributing to stress among construction practitioners' as Poor working conditions (MIS = 3.72), Work overload (MIS = 3.72), and financial problem (MIS=3.64). Findings from the study also revealed that task performance (MIS = 3.80) and technical performance (MIS = 3.76) are the most commonly used performance measures for construction practitioners. While reduced job satisfaction (MIS = 3.90) is the most significant impact stress has on construction practitioners' performance The study also found that work stress has a significant positive and slightly strong relationship with performance of construction practitioners with a value of 0.393. Therefore, Stress has both positive and negative impacts on the performance of professionals in construction. The major recommendations from the study were that management to ensure a sound working environment, and also implement flexible working hours (hybrid).

Keywords: Stress, Construction Practitioner, Performance.

Introduction

The building construction industry as witness transformations across the globe in the last few decades. Continuous changes in the development of building process, pace and complexity of work and increasing demand for higher productivity have become common features of the construction industry (Wong *et al.*, 2010). In addition, practitioners and other work force in the industry operate in an extremely competitive environment where projects are designed, constructed and delivered within tight budgets and a short duration. The whole processes have made works in the industry mentally and emotionally demanding and stressful (Wahab, 2010).

According to Daniel (2019), an average employee in the construction industry spends almost one third of his life on work, and sometimes has to face a lot of stress during his/her job. Daniel (2019) further lamented that stress in a workplace has touched almost all professions, from executive to workers who are directly engaged in the production. Job stress ultimately affects the physical as well as mental health. Stress has impact considerable impact on the lives of individuals. Although stress is a common concept, it is often misunderstood by many individuals. Stress is the way in which an individual respond to a range of environmental stressors. It is individualistic in nature and affects different people in different ways. Thus, what affects one person may not affect another (Blonna, 2012).

Lath (2010) asserted that although every person including a child, an adult, employed or unemployed faces stress in his/her everyday life. He defined stress as any challenge that exceeds the coping abilities of the individual. According to Patching and Best (2014), stresses a manifestation of different psychological factors such as an individual's personality type, their ability to be flexible, their understanding and use of avoidance and/or coping mechanisms, an individual's sleep and behaviour patterns, as well as their cognitive style, and how they learn. Lath (2010) asserted that although every person including a child, an adult, employed or unemployed faces stress in his/her everyday life. He defined stress as any challenge that exceeds the coping abilities of the individual. The causes and effects of psychological and occupational stress varies across different sectors of the economy. In the construction industry, professionals are exposed to stressful working conditions (Edwards and Irani, 2010). Sommovigo *et al.* (2019) added that construction related jobs are complicated, dynamic, crisis-ridden and involves high speed. These make construction employees vulnerable to occupational and psychological disorders and this has effects on themselves and the industry.

In education sector, Yusoff and Khan (2013) emphasized that stress is due to imbalance between job demands and their ability to respond. Employees are under pressure due to heavy workload, job demands and publication efforts given rise to tiredness, sleeping problem and concentration which are more visible when more workload is expected to attract external research funds. Similarly, Nithyajothi (2019) said that work life in the telecom industry is both challenging and stressful. Furthermore, Farber (2012) believes that we cannot eliminate stress but we can try to manage or cope with it at an optimal level. As such, understanding the causes is important in order to manage it. In developed economies, people are becoming more familiar with what work-related stress is and how to manage it. However, in developing countries like Nigeria. Since the human resource is an important resource to construction related organizations, efforts must be made to guard against any threats to this resource. It is important to understand the stress factors and make an effort to reduce those stressors in order to make effective and efficient use from of human resource (Sharma and Devi, 2011), and for them to be retained within the organization. Therefore, this study assessed the factors contributing to stress among of construction practitioners with a view to suggest strategies for effective management of stress.

The following objectives were formulated in order to minimise stress within the construction sector in the study area:

i. To assess factors contributing to stress among practitioners;

ii. To investigate the impact stress factor on construction practitioners' performance.

Literature Review

Factors Contributing to Stress among Construction Practitioners

Employees experience and feel stressed due to a set of various reasons and therefore the reactions to stress at the workplace are not a separate aspect (Fairbrother, and Warn, 2003). Increasingly, the stress level is changing rapidly among the employees due to various reasons, such as work overload, over crowdedness at the workplace, of loud noises generated by machines and arousal of conflicts among the employees and the employer due to poor or inadequate decisions (Richardson, 2014). Stress can arise because of transitions made in our personal lives. Personal issues that contribute to stress are domestic problems in the house, like losing loved ones, financial problems and divorce. These could be categorized as individual causes that lead to stress. On the other hand, there is also stress that is caused by organizational factors; these factors are those faced by the employees at the workplace. Issues such as role uncertainty; that is not being able to know exactly what one is supposed to do and what others expect from us and also having too much work at hand with little time to accomplish it, can cause stress at the work place. Further, organizational factors that causes stress are poor working conditions where the employee is often too distracted, where there is noise, where it is chilly or too hot and where the workplace is often filled with people running here and there. Whereas issues that contribute to stress are lack of control, suddenness, and ambiguity; especially role ambiguity is the foremost reason of stress at work (Richardson, 2014). Some organizational factors that can be considered as stressors mostly depend on the types of job and specification of works. These play important role regarding the issues related to stress, for instance, if the job is high-stress prone. High stress jobs are the kind of jobs that require plenty of time, and put the employees under the pressure of work. It is also notable that, often the employees suffer from poor working situation, if the work is performed in an unpleasant environment (Bloisi *et al.,* 2007).

Scholars have stated that a large number of features of occupational life, is connected to stress. Okeke *et al*. (2016), concluded their study by conducting a sample study of 7,099 employees from 13 different companies and occupations. They reported that a significant statistical relationship between workplace factor and negative symptoms of health or disorder of mental situation such as, anxiety, depression and irritation. Employees usually feel stress at their jobs due to the following reasons (Okeke *et al*., 2016);

a) Work overload; b) Misuse of power; c) Inadequate decisions or leader behaviour and d) Overcrowd and noise.

Work and workplace in them are stressful phenomenon and therefore, various aspects of work situations are connected to stress (De Silva *et al.*, 2017). According to Boschman *et al*. (2013), the factors related to roles in a work environment are namely existence of low-level power, role indefiniteness or role dispute. They added that increase in physical conditions at the workplace such as concurrent permanent noise, overcrowding and lack of secrecy, are associated to stress. The behaviour of the leader or chief can also affect the level of stress (Fairbrother, and Warn, 2003).

Impact of Work Stress Factors on Construction Practitioner's Performance

The findings of the investigation regarding the consequences of work stress experienced by employees at Khairun University showed a negative and significant effect on employee performance (Nur, 2013), Similarly Ramli (2017) and Yang and Hwang (2014) have tested the impact of work stress on employee performance their findings showed that organizational performance is based on collectively efforts of employees. According to Barlian (2016) if we can find out the causal relationship between the achievement of employee performance with organizational performance, it will be able to assist managers in directing the limited organizational resources in the right direction, which is the cause of improved employee performance, so that Organizations with workforce will be more satisfied and more efficient. Basri (2012) explained job stress as a negative feeling that due to individual's inability to face the weight of a workload or an inappropriate capacity or pressure at work. Productivity is considered to be at the peak with moderate level of work stress, but as it goes beyond that certain level, the productivity starts decreasing (Kakkos & Trivellas, 2011). Job stress can be viewed as an individual's reactions to characteristics of work environment that are perceived to be emotionally and physically threatening to the individual (Shahriari et al., 2013). It points to a poor fit between the individual's capabilities and his work environment, in which excessive demands are made of the individual or the individual is not fully prepared to handle the situation (Shahriari *et al.*, 2013). In general, the higher the imbalance between the demands and the individuals' abilities, the higher will be experienced job stress (Jamal, 2007).

Job performance can be viewed as an activity in which an individual is able to accomplish successfully the task assigned to him, subject to the normal constraints of the reasonable utilization of available resources (Shahriari *et al.*, 2013).

Job stress is often described as closely associated with performance and have serious implications on individual and organizational performance. Too much stress is clearly evidenced by a substantial decline in performance and organizational effectiveness (Manderson, 2014).

Measures of Performance of construction practitioners in the construction industry

A systematic literature review of 213 studies published in reputed journals or a period of only three years (2006-09) revealed 207 different measures used for assessing performance. There are various ways of assessing performance in construction sector, few of these ways are discussed below:

Technical Performance

Technical Performance Measurement is a process by which project management can measure the risks inherent in a given project. Technical Performance Measurements provide insight as to the parameters of the specific design elements of the system. Technical Performance Measurement is used by project management to define the measures of performance and acceptable variables during project implementation (Ahmad *et al.*, 2016). Use of Technical Performance Measurement benchmarks should be limited to factors which negatively affect the primary measures of performance, which are schedule and budget. Project management should not use Technical Performance Measurement to measure typical project goals, but strictly as a preventative measure to ensure that the project is delivered on time, and for the targeted budgetary goals. Studying these technical performance measurements provides the opportunity for management to develop tolerable risk ranges to evaluate the parameters of the project (Dziekonski *et al.*, 2018).

Social Performance

Social performance of construction projects reflects the extent to which the lifecycle of construction projects meets the demands of anticipated or existing social demands. Therefore, social performance of construction projects could be obtained by analyzing social impacts of construction projects and the requirements for social sustainability by diverse stakeholders. Shen *et al.* (2007) explored the indicators for social sustainability performance evaluation of different stages. Valdes-Vasquez *et al.* (2012) identified 50 processes for social sustainability consideration during planning and design phase of construction projects, and these processes were categorized into six categories, namely stakeholder engagement, user considerations, team formation, management considerations, impact assessment, and place context. Zuo *et al*. (2012) interviewed domain experts and 26 criteria of social sustainability were identified, which were further discussed from three dimensions, i.e., macro level, external stakeholders, and internal stakeholders. Liu et al. (2018), studied social impacts of an affordable housing project and indicators reflecting social impacts were discussed from three aspects as socio-economic effects, adaptabilities, and social risks. Wang *et al.* (2016); Shi *et al.* (2015), and Liu *et al.* (2016) also addressed the social risks of the construction projects. They suggested that the projects should not only be compliant with the regulations but also meet the requirements of diverse stakeholders, especially the end-users, which will improve project social flexibility and thereby contribute to project social sustainability.

Personal Performance

Personal Performance means each employee's work performance during the performance period which may be assessed by the administrator based on one or more criteria, including, but not limited to: personal or team performance and measures such as teamwork, interpersonal skills, communication skills, employee development, project management skills, and leadership, or individual or team business objectives such as performance versus budget and attainment of safety, operational incident and environmental standards (Jin *et al.*, 2013).

Organizational performance

There are possibly many interpretations of the term organizational performance. Luo *et al.* (2012) who conducted a meta-analysis of organizational performance suggested that it should be measured in economic and operational terms: The economic performance looks at financial and market outcomes which assess the profits, sales, return on investment for shareholders, and other financial metrices. The operational performance, on the other hand, focuses on the observable indices like customer satisfaction and loyalty, the firm's social capital, and competitive edge derived from capabilities and resources. Organizational performance is measured for different levels of hierarchy and can be assessed for individuals, groups, and the entire organization as a whole (Knies, Jacobsen and Tummers, 2016). The researchers settled on a multi-dimensional construct of organizational performance with financial performance, product market performance, and shareholder return forming three crucial aspects.

Research Methodology

This study adopted quantitative research design via questionnaire survey administered on construction practitioners in Kaduna State. Questionnaire survey adopted allows large coverage since there are various professional in the construction sector, it is also convenient and relatively inexpensive. Kaduna is selected because is one of the epicenters of construction activities in North West, Nigeria with high population of construction practitioners. The population of these professionals in Kaduna State is 429 based on summation of values gotten from each professional bodies in the State (such as Nigerian Institute of Architects (NIA), Nigerian Institute of Quantity Surveyors (NIQS), Nigerian Institute of Building (NIOB) and Nigerian Society of Engineers (NSE). Those that are financially up to date in their various professional bodies as at 2021 constituted the population, based on the information gotten from the record of each institution desk officers.

A sample is a small proportion of a population selected for observation and analysis. The sample size for this study was calculated using a formula as illustrated by Glenn (2013).

$$n = \frac{N}{1+N\,(e)2} \qquad (1)$$

Where;

n = Sample size

N = Population size in the sample unit

e = Level of precision which is + 5% (0.05)

$$n = \frac{429}{1 + 429\,(0.05)2} = 201 \qquad (2)$$

n= 201

To arrive at a sample size that served as a representative of the entire population in the study area equation 1 was used and an estimated sample size in which of 201 was gotten.

The analysis of the data was carried out using descriptive and inferential statistic such as mean item score, and Pearson product correlation respectively. A simple random sampling technique was adopted for the study. The questionnaire was designed on a five-point Likert scale format to address issues relating to the research objectives set.

Results and Discussion

Factors Contributing to Stress Among Practitioners in the Construction Industry

A total of thirteen (13) stress factors were identified from literature, and respondents were asked to rank these factors as contributing to stress among practitioners based on their impact. Table 1 shows the factors contributing to stress among practitioners. The top three (3) are poor working conditions, work overload, and financial problems, with MIS values of 3.72, 3.72, and 3.64 ranked 1st, 1st, and 3rd, respectively. At the bottom were the domestic problems in the home, overcrowding at work, and divorce are the least prevalent (3) factors, with MIS values of 2.62, 2.44, and 2.36 ranking 10th, 11th, and 12th, respectively. However, a close look at the results in Table 1 shows that all the identified factors contributing to stress among practitioners had an average MIS value of 3.11. This implies that, to a considerable extent, all the 13 factors contributing to stress among practitioners have the tendency to positively affect employee productivity and building projects. The finding of this study here agrees with Okeke *et al.* (2016) and De Silva *et al.* (2017), where it was established that employees usually feel stressed at their jobs due to work overload, misuse of power, and loud noises generated by machines.

Table 1: Factors contributing to stress among practitioners in the construction industry

S/N	Factors	MIS	Rank
g)	poor working conditions	3.72	1
h)	work overload	3.72	1
i)	financial problems	3.64	3
j)	Ambiguity of tasks	3.36	4
k)	behaviour of the leader	3.36	4
l)	Economic uncertainties such as redundancy and downsizings.	3.26	6
m)	Misuse of power	3.18	7
n)	loud noises generated by machines	3.12	8
o)	Role uncertainty by the employee	3.00	9
p)	Advancement in technology	2.62	10
q)	domestic problems in the house	2.62	10
r)	over crowdedness at the workplace	2.44	12
s)	Divorce	2.36	13
	General Average	*3.11*	

Source: Author 's Survey (2021)

Measures of Performance of Construction Practitioners in the construction industry

Five (5) measures of performance were identified from literature, and respondents were asked to rank their level of agreement with the identified measures. Table 2 shows the result of the analysis of the measures of performance of construction professional practitioners. Task performance and technical performance are the most commonly used measures of performance for construction professional practitioners in all types of workplaces, with MIS values of 3.80 and 3.76 ranking first and second, respectively. The least used measures of performance are personal performance and social performance, with MIS values of 3.62 and 3.30, ranked 4th and 5th, respectively. Table 2 shows that all the measures of performance of construction professional practitioners had an average MIS value of 3.63. This implies that, to a considerable extent, all 5 identified types of stress were experienced by the respondents.

Table 2: Measures of Performance of Construction Professional Practitioners in the construction industry.

S/N	Measures of Performance	MIS	Rank
1.	Task performance	3.80	1
2.	Technical Performance	3.76	2
3.	organizational performance	3.68	3
4.	personal performance	3.62	4
5.	Social Performance	3.30	5
	General Average	*3.63*	

Source: Author 's Survey (2021)

Impact factor of stress on construction practitioner's performance

In determine the impact of stress on construction practitioner's performance a null hypothesis was formulated:

H_0: There is no significant relationship between work stress and Performance of construction practitioners.

H_1: There is a significant relationship between work stress and performance of construction Practitioners'

The stress factors influence on construction practitioner's performance were correlated with the most significant measures of performance of construction professional practitioners (task performance). The analysis of the relationship between work stress and the performance of construction practitioners revealed that there exists a positive, slightly strong, and significant relationship between work stress and task performance. The result of the Pearson product moment correlation analysis is presented in Table 4. The correlation value was positive and slightly strong (0.393). The correlation was therefore found to be significant at a 1% (0.01) level of significance (p = 0.00). Therefore, the alternate hypothesis that states there is a significant relationship between work stress and the performance of construction practitioners was accepted. The relationship between stress and job performance or the impact of occupational stress on performance has been a topic of academic interest over the years. The findings of this study on correlation analysis agree with the findings of other studies where a relation between stress and performance has been proved in various sectors of society, such as the banking industry (Shaik *et al.*, 2013), hospital industry (Nabirye, 2010), hotel industry (Olaniyi, 2013), high-tech industries (Hsieh, Huang, & Su, 2004), business (Dar, Akmal, Naseem, & Khan, 2011) and the educational sector (Riyadi, 2015; Suandi, Ismail, & Othman, 2014).

Table 3: Results of Pearson Product Correlation Analysis

Correlations		Work stress	Task performance
Work stress	Pearson Correlation	1	.393**
	Sig. (2-tailed)		.000
	N	200	200
Task performance	Pearson Correlation	.393**	1
	Sig. (2-tailed)	.000	
	N	200	200

**. Correlation is significant at the 0.01 level (2-tailed).

Conclusions and Recommendations

The results of the analysis carried out led to the conclusions of this study. The study identified the major three (3) most prevalent factors contributing to stress among construction practitioners' as Poor working conditions (MIS = 3.72), Work overload (MIS = 3.72), and financial problem (MIS=3.64). Findings from the study also revealed that construction workers performance is measured based on task performance (MIS = 3.80) and technical performance (MIS = 3.76). The most significant ways stress impacted on construction practitioner's performance is reduced job satisfaction. The most effective strategies for mitigating the effects of stress among practitioners in the construction industry are: to understand when there is a decrease in performance and absenteeism. Stress usually builds up gradually in a normal situation and more stress causes more problems. There is a significant relationship between work stress and the performance of construction practitioners Stress has both positive and negative impacts on the performance of professionals in construction. The major recommendations from the study were that management to ensure a sound working environment, and also implement flexible working hours (hybrid).

References

Ahmad, J., Muhammad, R., & Hussain, M. (2016), Linking Personality Traits with Job Performance Mediating Role of Organizational Commitment: An Empirical Evidence. NUML International Journal of Business & Management, 11(2), pp. 1-11.

Barlian, N.A. (2016). Personality and job performance: test of the mediating effects of motivation among sales representatives. Journal of Applied Psychology, 87(1), pp. 43

Basri, G., (2012). Commitment Devices. Annual Review of Economics, 2(1), pp. 671–698.

Bloisi, W., Cook, C.W., &Hunsaker, P. L. (2007). Management and Organizational

Behaviour. 2th Edition. London: McGraw publication.

Blonna, R. (2012). Coping with Stress in a Changing World. 5th edition. New York, NY: McGraw- Hill.

Boschman, J.S., Van der Molen, H.F., Sluiter, J.K. and Frings-Dresen, M.H.W., (2013). Psychosocial work environment and mental health among construction workers. Applied ergonomics, 44(5), pp. 748-755.

Dar, L., Akmal, A., Naseem, M. A., & Khan, K. U. D. (2011). Impact of Stress on Employee's Job Performance in Business Sector of Pakistan. *Global Journal of Management and Business Research*, 11(6), 1–5.

Daniel, C. O. (2019). Effects of job stress on employee's performance. International Journal of

Business, Management and Social Research, 06(02), pp. 375-382.De Silva, N., Samanmali, R. and De Silva, H.L., (2017). Managing occupational stress of

professionals in large construction projects. Journal of Engineering, Design and Technology, 15(4), pp. 488- 504.

Dziekonski, E.T., Johnson, J.T., Lee, K.W., McLuckey, S.A. (2018). Determination of collision cross sections using a Fourier transform electrostatic linear ion trap mass spectrometer. Journal of the American Society for Mass Spectrometry, 29 (2), pp. 242–250.

Edwards, D.J. & Irani, Z. (2010). Work stress, support, and mental health in construction. Journal of Construction Engineering and Management, 136(6), pp. 650-658.

Fairbrother, K., & Warn, J. (2003). Workplace dimensions, stress and job satisfaction. Journal of Managerial Psychology, 18(1), pp. 8-21.

Farber, B. A. (2012). Stress and Burnout in Suburban Teachers. Journal of Administration; 31, pp. 189-210

Glenn, J. C. (2013). Collective Intelligence and an Application by The Millennium Project. Sage Journal, 5(3), pp. 235-243.Available on at https://doi.org/10.1177/1946756713497331.pfd [accessed 25 October 2021].

Hsieh, H., Huang, L.-C., & Su, K. (2004). Work Stress and Job Performance in the Hi-Tech Industry: A Closer View for Vocational Education. *World Transactions on Engineering and Technology Education*, 3(1), 147–150.

Jamal, M. (2007). Job stress and job performance controversy revisited: An empirical examination in two countries. International Journal of Stress Management, 14(2), pp. 175- 187.

Jin, Z., C. Lukashin, Y. Qiao, and A. Gopalan, (2013). An efficient and effective method to simulate the earth spectral reflectance over large temporal and spatial scales. Geophys. Res. Lett., 40(2), pp. 374-379.

Kakkos, N., & Trivellas, P. (2011). Investigating the Link between Motivation, Work stress and Job Performance. In Proceedings of the 8th International Conference on Enterprise Systems, Accounting and Logistics: motivation_work_stress_and_job_performance_Evidence_from_the_banking_industry, pp.408–428, 10-12 July 2011, Thasos, Greece. Retrieved from https://www.researchgate.net/publication/267768551_Investigating_the_link_between.

Knies, E., Jacobsen, C.B., & Tummers, L.G. (2016). Leadership and organizational performance: State of the art and research agenda.

Lath, S.K. (2010). A Study of the occupational stress among teachers. International Journal of Education Administration, 2(2), pp. 421-432

Liu, Z.-Z.; Zhu, Z.-W.; Wang, H.-J.; Huang, J (2016). Handling social risks in government driven mega project: An empirical case study from West China. *International Journal of Project Management*, 34, 202–218.

Liu, B.; Li, Y.; Xue, B.; Li, Q.; Zou, P.X.; Li, L (2018). Why do individuals engage in collective actions against major construction projects? —An empirical analysis based on Chinese data. *International Journal of Project Management*, 36, 612–626.

Luo. Y., Huang, Y., and Stephanie, L. W. (2012). Guanxi and Organizational Performance: A Meta-Analysis. Management and Organization Review, 8(1), pp. 139–172

Manderson, C. C.-G. (2014). Life Stress, Work stress and Job Performance: Does Conscientiousness makes a Difference? (Master's Thesis). California State University, Long Beach, California.

Nabirye, R. C. (2010). *Occupational Stress, Job Satisfaction and Job Performance among Hospital Nurses in Kampala Uganda*. (Doctoral Thesis). University of Alabama, Birmingham, South Africa. Retrieved from http://www.mhsl.uab.edu/dt/2010r/nabirye.pdf

Nithyajothi, G. (2019). The impact of job stress, workload and long working hours on the job satisfaction of government doctors at tamil nadu. I-Manager's Journal on Management, 14(1), pp.25. Retrieved from https://doi:10.26634/jmgt.14.1.15207.

Nur, Saina (2013). Konflik, Stres Kerja Dan Kepuasan Kerja Pengaruhnya Terhadap Kinerja Pegawai Pada Universitas Khairun Ternate. Journal EMBA, 1(3), pp. 739-749.

Olaniyi, A. A. (2013). *Effects of Job Stress and Motivation on Performance of Employees in Hotel Industry (Hotels at Dublin Airport).* (Bachelor's Thesis). National College of Ireland, London. Retrieved from http://trap.ncirl.ie/910/1/aolaniyi.pdf

Okeke, M.N., Echo, O. and Oboreh, J.C., (2016). Effects of Stress on Employee Productivity. International Journal of Accounting Research, 42(3495), pp. 1-12.

Patching, A., & Best, R. (2014). An investigation into psychological stress detection and management in organizations operating in project and construction management. Procedia - Social and Behavioural Sciences, 119, pp. 682-691.

Ramli, AH. (2017). Organizational commitment and Employee Performance at Distributor Company. Business And Entrepreneurial (BER), 17(1), 17-30.

Richardson, F.W., (2014). Enhancing strategies to improve workplace performance (Doctoral dissertation, Walden University).

Riyadi, S. (2015). Effect of Work Motivation, Work Stress and Job Satisfaction on teacher Performance at Senior High School (SMA) Throughout the State Central Tapanuli,

Sumatera. *IOSR Journal of Humanities and Social Science*, 20(2), 52–57.http://doi.org/10.9790/0837-20215257

Shahriari, J. E., Meyvand, M., Koolivand, P., & Maleki, J. (2013). Influential Factors on Job Stress and its Effect on the Employee's Performance Among Bank Sepah Branches in Tehran. Indian Journal of Fundamental and Applied Life Sciences, 3(3), pp. 446–451.

Shaikh, A. A., Akram, M., Rizwan, M., Kousar, S., & Malik, M. (2013). The Impact of Job Stress: An Imperative Insight into the Banking sector. *Journal of Public Administration and Governance*, 3(3), 294–316. http://doi.org/10.5296/jpag.v3i3.6223

Sharma, J., & Devi, A. (2011). Role stress among employees: An empirical study of commercial banks. Gurukul Business Review, 7.

Shen, L.Y.; Hao, J.L.; Wing, V.; Tam, Y.; Yao, H. A (2007). checklist for assessing sustainability performance of construction projects. Journal of Civil Engineering Management, 13, pp. 273-281.

Shi, Q.; Liu, Y.; Zuo, J.; Pan, N.; Ma, G (2015). On the management of social risks of hydraulic infrastructure projects in China: A case study. International Journal of Project Management, 33, pp. 483–496.

Sommovigo, V., Setti, I., O'Shea, D., & Argentero, P. (2019). Investigating employees' emotional and cognitive reactions to customer mistreatment: An experimental study. European Journal of Work and Organizational Psychology, 29(5), pp. 707–727.

Valdes-Vasquez, R.; Klotz, L.E (2012). Social sustainability considerations during planning and design: Framework of processes for construction projects. Journal of Construction. Engineering Management, 139, pp. 80–89.

Wahab, A. B (2010). 'Stress management among artisans in construction industry in Nigeria', Global Journal of Researches in Engineering, 10 (1), pp. 93-103

Wang, Y.; Han, Q.; de Vries, B.; Zuo, J (2016). How the public reacts to social impacts construction projects? A structural equation modelling study. International Journal of Project Management, 34, pp. 1433–1448.

Wong, N. T., Zimmerman, M. A., & Parker, E. A. (2010). A typology of youth participation and empowerment for child and adolescent health promotion. American Journal of Community Psychology, 46, pp. 100-114. https://doi: 10.1007/s10464-010-9330-0

Yang, C.-L. and Hwang, M. (2014). "Personality traits and simultaneous reciprocal influences between job performance and job satisfaction", Chinese Management Studies, 8(1), pp. 6-26.

Yusoff, R. B. M., and Khan, A., (2013). Job Stress, Performance and Emotional Intelligence in Academia. Journal of Basic and Applied Science Research, 3(6), pp. 1- 8.

Zuo, J.; Jin, X.-H.; Flynn, L (2012). Social sustainability in construction–an explorative study. International Journal of Construction. Management, 12, pp. 51–63

Design Measures for Health and Safety in Pre-Construction Stage of Public Building Projects in Nigeria

Adekunle, A.[1a], Alumbugu, P.[1b] and Mohammed, Y.[1c]
1 Department of Quantity Surveying, Federal University of Technology, Minna, Niger State, Nigeria
ebenezer.adekunle@st.futminna.edu.ng; polycarp@futminna.edu.ng; m.yakubu@futminna.edu.ng
corresponding author: ebenezer.adekunle@st.futminna.edu.ng

Abstract:

Construction project design is a key contributor to accidents and injuries on construction sites. Although design for health and safety (H&S) concept is a potent means of ensuring the safety of workers on construction site, architects and design engineers are reluctant to adopt this approach as their standard practice. To date, no study has comprehensively examined how well the H&S of workers are considered during the design stage of public building projects in Nigeria. To fill this gap, this research has provided an evidence-based assessment of H&S considerations in the pre-construction stage of public building projects in Nigeria. Data were collected from architects, builders and civil and structural engineers in Abuja through well-structured questionnaires. The data was subjected to statistical analysis using Relative Importance Index (RII) to assess the level at which design measures for H&S are considered in pre-construction stage of public building projects. The findings of this study revealed that out of the forty-one design measures for safe construction identified from literature, only four had high consideration, while 19 had moderate consideration, 17 had little consideration, and one had very little consideration. It was therefore concluded that there is no prime consideration for key design issues related to H&S in pre-construction stage of public building projects. Major recommendation from the study was that building designers working for public clients and contracting firms should make conscious effort to eliminate hazards through the design process to ensure safe construction.

Keywords: Construction, Design, Health, Pre-construction, Safety.

Introduction

The Nigerian construction industry has the second highest profile of accidents and fatalities of human lives among other sectors (NOSHIC, 2006). Lack of concern, accurate records and statutory regulations make the Nigerian construction industry worse than the developed countries in terms of safety issues (Idoro, 2008). Larger contractors within the industry record high numbers and rates of injuries on their site (Idoro, 2011). Although there are multiple and complex factors responsible for construction accidents, construction project design has been identified as one of the major contributors to accident and injuries (Haslam et al., 2005). According to the construction design management (HSE, 2015), the word design is inclusive of drawing, design details, specifications, bills of quantity and calculations prepared for the purpose of a design. Manu et al. (2018) affirmed that safety-oriented design is crucial to mitigating the occurrence of injuries and illness in construction. Manu et al. (2018) further noted that most safety design related studies are geared towards developed countries with a limited focus on developing countries. Consequently, no study has fully assessed the level at which design measures for H&S are considered at the pre-construction stage of public building projects in Nigeria.

Therefore, this study aimed to provide an evidence-based assessment of how well workers' H&S are considered in pre-construction stage of public building projects. This study specifically identified the major and applicable H&S design measures in pre-construction stage of public building project, and also assessed the level to which these H&S design measures are considered by construction industry professional designers including architects, builders, civil and structurer engineers, and electrical engineers.

Design for health and safety in construction

Previous studies have shown that the construction sector has made considerable progress in accident prevention and risk management, but several issues within the industry, including lack of design for safety are impeding the achievement of a long-term goal of zero injuries. The construction safety design process is meant to address site safety and health issues in the design and planning stage of a project, which is a key phase for effectively addressing H&S concerns (Rwamamara and Holzmann, 2007; Behm et al., 2014). The majority of construction faults occur during the pre-construction phase of work, and failures can occur in the technical parts of design, which are by their very nature tied to planning and organisation concerns (Giessa et al., 2017). According to Behm et al. (2014), designers are in a unique position to spot and eliminate hazards at their source, as well as reduce unnecessary risk throughout the business. The identified hazards are established through design decision, and construction management professionals and workers are allowed to handle the risks as best they can.

According to Smallwood (2008), designers have a direct and indirect influence on construction ergonomics. Design, details, and manner of fixing have a direct impact, as do supervisory and administrative interventions, depending on the type of procurement system. The indirect impact is due to the procurement system employed, pre-qualification, project time, collaboration, and pre-planning facilitation. Gambatese (2005), however, noted that architects and design engineers (Design team) are reluctant to adopt and implement this intervention as their standard practice. Gambatese (2005) also identified lack of motivating forces such as legal, contractual or regulatory forces as the factors responsible for the delay in the implementation of design for H&S method by the design team. Hence, the likelihood of little consideration for H&S design measures at the project design stage.

Level of design for health and safety consideration

During the schematic and design development phases of a construction project, designers' decisions have a direct impact on the H&S of construction workers on the jobsite (Behm et al., 2014). When designing buildings and other structures, designers consider the H&S of end users, but comparable issues for construction workers during the development process are often disregarded (Rwamamara, 2005; Hecker et al., 2006). In occupational health and safety, the hierarchy of controls and hazard elimination recognises that engineering controls and hazard elimination through design are superior to administrative controls and personal protective equipment in reducing worker exposure (Hecker et al., 2006). Architects and engineers are almost exclusively concerned with the H&S of the building end-users, rather than the people who construct it. In Swedish research, for example, when asked whether they address health issues in their designs, a lot of architects stated that their designs consider the H&S of the end-users rather than the construction workers (Rwamamara, 2005). Boadu et al. (2021) explored the level to which H&S are considered in the procurement of public sector projects in Ghana and found that H&S is given minimal priority during the procurement of public projects. This resulted from absence of clear project objectives relating to H&S and inadequate consideration given to H&S at the various procurement stage.

According to Toole and Gambatese 2008, construction (design and management) regulations provide designers with the responsibility of ensuring the H&S of construction employees. It makes the designer responsible for ensuring that any design avoids unnecessary and foreseeable risks to workers. However, the success of construction design management (CDM) in decreasing construction deaths has been difficult to prove, because designers in the UK have been slow to satisfy their responsibilities under the building standards (Behm, 2005). Brace et al. (2009) noted that, despite fifteen years of CDM, many designers are not convinced about its relevance. This creates a major concern for developing countries such as Nigeria with track record of high rate of fatalities.

Many designs for H&S measures are mentioned in the literature. Project positioning and layout, material selection, contractor storage locations, mechanical and electrical installations, falling from heights, trenches, communicating hazards to contractors, sequence of work and maintenance requirements for safety, construction documentation, and work schedule are all covered by the design for H&S measures (Al-Hajj and Hamani, 2011; Site Safe, 2019). Rwamamara and Holzman (2007) also identified from literature five areas to focus design improvement effort, which include the access for material and equipment, workers' anthropometry and access, the size and the weight of materials, prefabricated buildings, and temporary works. Proper consideration of these measures by designers through the design phase can improve workers' safety during the implementation and maintenance stages.

Methodology

This research employed the quantitative research approach to assess the level of consideration for H&S design measures at the pre-construction stage of public building projects. In general, quantitative research permits the collection of data and its statistical analysis in order to ascertain the veracity of theories or hypotheses (Creswell, 2009). Therefore, the quantitative approach was suitable to explore how well workers' H&S are considered at the design stage of public building projects in Abuja, Nigeria.

The sampling frame involved a population of construction industry professionals who have direct and indirect involvement in the procurement process for public projects. The purposive sampling method under non-probability sampling techniques was used to select participants, with relevant experience in the procurement process of public building projects. These participants were drawn from various organisations, including, contractors, consultants, and government institutions. A total of 200 survey questionnaire were distributed to participants and 65 were collected and deemed valid. Thus, resulting in a response rate of 33%. This is relatively high, considering that the response rate in construction management research is widely acknowledged to be low (Root and Blismas, 2003). Higher response rate **is** appropriate in a survey; however, it does not necessarily result in most accurate conclusions (Keeter *et al*., 2006).

The structured questionnaires were designed to investigate the level to which design measures for H&S are considered at the pre-construction stage of public building projects in Abuja, Nigeria. The respondents were guided on a five-point Likert scale, ranging from 1 to 5, where 1 = very little, 2 = little, 3 = moderate, 4 = high, and 5 = very high. The Cronbach's alpha test was conducted to verify the internal consistency reliability of the design measures in each group. Cronbach's alpha offers the appropriate test to assess reliability across items, because it estimates the reliability based on the correlations between the items (Hair et al., 2009). Besides, internal consistency ranging from 0.50 to 0.70 is acceptable, 0.70 to 0.90 shows high internal consistency, and 0.90 and above represents excellent reliability (Hinton et al., 2004).

The collected data was analysed by using descriptive statistic method including Relative Importance Index (RII). The decision rule for the outcome of the RII was decided on the following: 0.911-0.979 for very high; 0.841-0.910 for high; 0.772-0.840 for moderate; 0.702-0.771 for little; and 0.632-0.701 for very little. This type of decision rule was used by Atilola *et al*. (2019).

Result and discussion

Demographic profile of respondents

Table 1 shows the respondents profession, 44.62% are electrical engineers, 24.62% are builders, 20% are architects, and 10.77% are civil and structural engineers. This reveals that major professions within the construction industry are well represented in the study.

Table 1: *Demographic profile of respondents*

S/n	Category	Classification	Frequency	Percentage
1	Respondent Profession	Architect	13	20.00%
		Builder	16	24.62%
		Civil and Structural Engineer	7	10.77%
		Electrical Engineer	29	44.62%
		TOTAL	**65**	**100.00%**
2	Years of experience	Less than 5 years	9	13.58%
		5 - 10 years	21	32.31%
		11 - 15 years	16	24.62%
		16 - 20 years	7	10.77%
		Above 20 years	12	18.46%
		TOTAL	**65**	**100.00%**

Table 1 also shows the respondents working experience. 32.31% had 5 – 10 years of working experience, 24.62% had 11 – 15 years, 18.46% had above 20 years, and 13.58% had less than 5 years. The lowest being 16 – 20 years of experience, comprising 10.77% of the respondents. This shows that the respondents are well experienced in providing valuable information for this study. In addition, 73.85% of the respondents work in government organisation, while 15.38% work with contractors and 10.77% are with consultants. This indicates that most of the respondents are capable of providing valid information for the research.

Level of consideration of design measures for health and safety in pre-construction stage of public building projects

A total of forty-one (41) design measures for safe construction were identified from literature and categorised into eight (8) sections.

Design for material and equipment access

Seven design measures under material and equipment access were assessed. Table 2 indicates that the top three design measures for H&S considered for material and equipment access design are: access area to accommodate work-at-height equipment; equipment and material to be delivered and removed during and after construction work; and creation of realistic methods statements which indicate machinery, tools and the mode of operation, with RII of 0.846, 0.837 and 0.794, respectively. Installation of vertical wall hatches on all floors that allow machine stocking and mechanised lifting, and specifying plant with low noise are among the least considered material and equipment access design measures, with RII values of 0.772 and 0.763 respectively. The result further shows that only access area to accommodate work-at-height equipment is highly considered in the design for material and equipment access, while little consideration is given to specifying plant with low noise.

Design for workers' anthropometry and access

Three design measures under workers' anthropometry and access requirements were assessed. Table 2 shows that the top design measure for H&S considered during the design for workers' anthropometry and access is arrangement of space to promote access during work and after completion, with RII value of 0.815. Minimisation of the number of confined spaces was the least ranked design measure for workers' anthropometry and access, with RII value 0.775. All design considerations in this category are moderate.

Design for manual handling

Six design measures under manual handling were assessed. Table 2 shows that methods of material handling, loading docks and storage facilities and accessibility of material handling, with RII values of 0.788 and 0.769 respectively, are the key design measures considered in the design for manual handling. Size and weight of material and assembly and disassembly of prefabricated fixtures and fitting were among the least design measures considered in the design for manual handling, with RII values of 0.754 and 0.748 respectively.

Design for prefabrication

Three design measures under prefabrication were assessed. Table 2 reveals that the design measure for H&S mainly considered during the design for prefabrication is limiting the size of prefabricated wall panels where site access is restricted, with RII value of 0.775. Increase usage of pre-assembly/prefabricated components and relocation of work from the construction site to a factory were among the least ranked design measures considered during the design for prefabrication, with RII values of 0.757 respectively.

Design for temporary work

Four design measures under temporary work were assessed. Table 2 further indicates that specification of erection practice for scaffolds is the major design measure for H&S considered during the design for temporary works, with RII value of 0.843, while temporary work platforms, use of debris guards, netting and fans for high-rise scaffolds, and load bearing scaffolds were among the least considered design measures, with RII values of 0.809 and 0.803 respectively.

Design for movement of people

Five design measures under movement of people were assessed. Table 2 indicates that site security and safe crossing are the top design measures for H&S considered during the design for movement of people, with RII values of 0.862 and 0.775 respectively. Traffic management and exclusion zone with RII values of 0.757 and 0.698 were among the least ranked design measures for H&S considered during the design for movement of people.

Design for working environment

Five design measures under working environment were assessed. It was revealed from Table 2 that the top design measure for H&S considered during the design for working environment is lighting including that of plant room, and ventilation for thermal comfort and specific ventilation requirements for the work to be performed on the premises, with RII value of 0.849 and 0.831 respectively. Space for occupants and acoustic properties and noise control were among the least ranked design measures for H&S considered during the design for working environment, with RII values of 0.785 and 0.754 respectively.

Design for information recording and transfer

Eight design measures under information recording and transfer were assessed. Table 2 indicates that methods of access where normal methods of securing scaffold are not available; features of the design essential to safe operation; and temporary work required to construct the building as design are the major design measures for H&S considered for information recording and transfer, with RII value of 0.791, 0.775 and 0.760 respectively. Features that create access problems, heavy or awkward prefabricated elements likely to create handling risks, and noise and vibration hazard from plant were among the least considered design measures, with RII values of 0.726 and 0.723 respectively.

Table 2: *Design for health and safety measures at the pre-construction stage of public building projects*

S/n	Design Measures	RII	Rank	Decision
	Design for Material and Equipment Access			
DMEA1	Access area to accommodate work-at-height equipment	0.846	1	H
DMEA2	Equipment and material to be delivered and removed during and after construction work	0.837	2	M
DMEA3	Creation of realistic methods statements which indicate machinery, tools and the mode of operation	0.794	3	M
DMEA4	Floor loading to accommodate heavy machinery	0.785	4	M
DMEA5	Maintenance access to plant and equipment	0.785	4	M
DMEA6	Installation of vertical wall hatches on all floors that allow machine stocking and mechanised lifting	0.772	5	M
DMEA7	Specifying plant with low noise	0.763	6	L
Average		0.794		
	Cronbach's alpha = 0.904			
	Design for Workers' Anthropometry and Access			
DWAA1	Arrange space to promote access during work and after completion	0.815	1	M
DWAA2	Devise tools, gear and workstations to fit workers bodies	0.794	2	M
DWAA3	Minimise the number of confined spaces	0.775	3	M
Average		0.795		
	Cronbach's alpha = 0.824			
	Design for Manual Handling			
DMH1	Methods of material handling	0.788	1	M
DMH2	Loading docks and storage facilities	0.788	1	M
DMH3	Accessibility of material handling	0.769	2	L

DMH4	Workplace space and layout to prevent musculoskeletal disorder	0.766	3	L
DMH5	Size and weight of material	0.754	4	L
DMH6	Assembly and disassembly of prefabricated fixtures and fitting	0.748	5	L
Average		0.769		
	Cronbach's alpha = 0.884			
	Design for Prefabrication			
DP1	Limiting the size of prefabricated wall panels where site access is restricted	0.775	1	M
DP2	Increase usage of pre-assembly/prefabricated components	0.757	2	L
DP3	Relocation of work from the construction site to a factory	0.757	2	L
Average		0.763		
	Cronbach's alpha = 0.823			
	Design for Temporary Works			
DTW1	Specification of erection practice for scaffolds	0.843	1	H
DTW2	Temporary work platforms	0.809	2	M
DTW3	Use of debris guards, netting and fans for high-rise scaffolds	0.809	2	M
DTW4	Load bearing scaffolds	0.803	3	L
Average		0.816		
	Cronbach's alpha = 0.835			
	Design for Movement of People			
DMP1	Site security	0.862	1	H
DMP2	Safe crossing	0.775	2	M
DMP3	Safe access and egress, including for people with disability	0.760	3	L
DMP4	Traffic management	0.757	4	L
DMP5	Exclusion zone	0.698	5	VL
Average		0.770		
	Cronbach's alpha = 0.855			
	Design for Working Environment			
DWE1	Lighting including that of plant room	0.849	1	H
DWE2	Ventilation for thermal comfort and specific ventilation requirements for the work to be performed on the premises	0.831	2	M
DWE3	Floor surfaces to prevent slips and trip	0.797	3	M
DWE4	Space for occupants	0.785	4	M
DWE5	Acoustic properties and noise control	0.754	5	L
Average		0.803		
	Cronbach's alpha = 0.886			
	Information Recording and Transfer			
IRT1	Methods of access where normal methods of securing scaffold are not available	0.791	1	M
IRT2	Features of the design essential to safe operation	0.775	2	M
IRT3	Temporary work required to construct the building as design	0.760	3	L
IRT4	Any parts of the design where risks have been minimised but not eliminated	0.757	4	L
IRT5	Hazardous substance or flammable materials included in the design	0.748	5	L
IRT6	Features that create access problems	0.726	6	L
IRT7	Heavy or awkward prefabricated elements likely to create handling risks	0.723	7	L
IRT8	Noise and vibration hazard from plant	0.723	7	L
Average		0.750		
	Cronbach's alpha = 0.914			
	Overall Average = 0.781			

VL=Very Little, L=Little, M=Moderate, H=High

Summary of the level of consideration of design measures for health and safety at the pre-construction stage of public building projects

All the design measures assessed are applicable at the pre-construction stage of public building projects and were adopted from the literature (Rwamamara and Holzmann, 2007; Site Safe, 2019) and categorised into eight sections. The relative importance of these design measures and their rankings are presented in Table 3. The result shows that design for temporary works ranked 1st (RII = 0.816), design for working environment 2nd (RII = 0.803), design for workers' anthropometry and access 3rd (RII = 0.795), design for material and equipment access 4th (RII = 0.794), design for movement of people 5th (RII = 0.770), design for manual handling 6th (RII = 0.769), design for prefabrication 7th (RII = 0.763), and information recording and transfer 8th (RII = 0.750).

Table 3: *Summary of design for H&S consideration at the pre-construction stage*

Code	**Design Consideration**	**Average RII**	**Cronbach's Alpha**	**Rank**	**Decision**
DTW	Design for Temporary Works	0.816	0.835	1	M
DWE	Design for Working Environment	0.803	0.886	2	M
DWAA	Design for Workers' Anthropometry and Access	0.795	0.824	3	M
DMEA	Design for Material and Equipment Access	0.794	0.904	4	M
DMP	Design for Movement of People	0.770	0.855	5	L
DMH	Design for Manual Handling	0.769	0.884	6	L
DP	Design for Prefabrication	0.763	0.823	7	L
IRT	Information Recording and Transfer	0.750	0.914	8	L

M =Moderate, L=Little

Discussion of results

The findings of this study show the top H&S design measures considered by construction professionals under eight categories. These highly ranked measures ranges from access area to accommodate work-at-height equipment to temporary work required to construct the building as design. This establishes the argument of Boadu et al. (2021) that H&S concerns are not restricted to construction phase but are relevant at the design and planning phase of construction projects. It was discovered that the general level of H&S consideration at the design stage is moderate, which indicates a significant improvement among designers contrary to the assertion of Rwamamara (2005) and Hecker et al. (2008) that designers consider the health and safety of end users during building and other structures design but ignored comparable issues for construction workers during the design process. Besides, this is similar to the condition in the United States, where the design for health and safety concept was slowly recognized and applied for more than 20 years (Behms et al., 2014). However, Behms et al. (2014) asserted that worker's safety ought to be a prime consideration of planners and designers in the conceptual and preliminary design phases, because the planning and design phases enables the elimination of hazards before they appear on the construction site.

Further, most of the design considerations fall within the range suggested by Rwamamara and Holzmann, (2007), Behms et al. (2014) and Ajayi and Thwala (2015), which include but not limited to: adjustments to the permanent characteristics of the project that make the facility automatically safer to build; the use of specialized design for construction safety recommendations; the disclosure of design-related hazards in connection to the work-site and the design; and site layout planning. The little level of consideration given to some of the H&S design measures in pre-construction stage indicates that some of the designers are not anticipatory thinkers; and though they may be aware of the design process, negligence or ignorance of the consequences of their actions subsist. This agrees with the view of Rwamamara and Holzmann, (2007) and Luczak *et al*. (2006). In summary, the general level of H&S consideration at the design stage was moderate, with overall average RII value of 0.781. Therefore, it implies the need for improvement on the requirements for consideration during the design. Thus, adequate attention and consideration should be given by the professional to the requirement ranked 1st – 3rd in each of the eight categories to enhance H&S in the design stage.

Conclusions

This study has delivered an evidence-based assessment of the extent to which design measures for H&S are considered at the pre-construction stage of public building projects in Abuja, Nigeria. This is based on the premise that designing to eliminate hazard at the pre-construction stage is more effective than controlling the hazard or protecting the workers from the hazard, and it also contribute to significant reduction in injuries. Besides, the public sector clients, with the highest purchasing power within the construction industry, can influence the practice of the industry by considering design for H&S at the pre-construction stage, thus challenging the traditional method that places the whole H&S responsibilities on the contractor. In spite of the moderate level of consideration indicated by the findings of the study, major design measures for H&S are still given little priority at the pre-construction stage of public building projects, hence there is no prime consideration for design measures related to H&S.

To advocate for better design for H&S practice, it is important to understand the level to which design measures for H&S are considered at the pre-construction stage. Building designers working for public clients and contracting firms must make conscious effort to eliminate hazards through the design process to ensure safe construction.

Acknowledgements

The project team comprise Mr. Ebenezer Adekunle, Dr. Polycarp Alumbugu and Dr. Yakubu Mohammed. The authors would like to express sincere gratitude to the reviewer of this paper and the organising committee of the conference for their constructive and helpful comments to enhance the quality of the initial versions of this paper.

References

Ajayi, O. and Thwala, W.D. (2015) Developing an integrated design model for construction ergonomics in Nigeria construction industry. *African Journal of Applied Research*, 1(1), 478-495.

Al-Hajj, A., and Hamani, K., (2011) Material waste in the UAE construction industry: Main causes and minimization practices. *Architectural Engineering and Design Management*. 7 (4), pp. 221–235.

Atilola, M.I., Ismail A., Achu K., and Bujang, A.A. (2019) An evaluation of factors causing variance in property assessment. *Journal of the Malaysian Institute of Planners*, 17(1), pp. 82-93.

Behm, M. (2005). Linking construction fatalities to the design for construction safety 562 concept. *Safety Science*. 43(8), pp. 589-611.

Behms, M., Gambatese J., and Toole, T.M. (2014) Construction Safety and Health through Design. Construction Safety Management and Engineering, 2nd Ed. Darryl C. Hill, Editor. Des Plaines, IL: American Society of Safety Engineers.

Boadu, E. F., Sunindijo, R.Y. and Wang, C.C (2021) Health and safety consideration in the procurement of public construction projects in Ghana. *Buildings*, 11, 128.

Brace, C., Gibb, A., Pendlebury, M., and Bust, P. (2009) Phase 2 Report: Health and safety in the construction industry: underlying causes of construction fatal accidents–external research. London, UK.

Creswell, J.W. (2009). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches; Sage: Los Angeles, CA, USA.

Gambatese (2005) Investigation of the viability of designing for safety. The Center to Protect Workers' Rights. Silver Spring, MD. May.

Giessa M.M., Rashid I. A., Abu El-Soud S., and El-Tahan A.H. (2017) Costing the health and safety in the Egyptian building construction projects. *Journal of Al Azhar University Engineering Sector*, 12 (42), pp. 55-67.

Global Construction Perspectives and Oxford Economics (2013) Global construction 560 2025. London: Global Construction Perspectives and Oxford Economics.

Hair, J.F., Black, W.C., Babin, B.J., and Anderson, R.E. (2009) Multivariate Data Analysis, 7th ed.; Prentice Hall: Upper Saddle River, NJ, USA.

Haslam R.A., Hide S.A., and Gibb A.G.F. (2005) Contributing factors in construction 564 accidents. *Applied Ergonomics*, 36(4), pp. 401-415.

Hecker, S.F., Gambatese, J.A., and Weinstein, M. (2006) Designing for construction safety in the U.S.: Progress, needs, and future directions. Proceedings IEA2006 Congress, July 10-15, Maastricht, Netherlands.

Hinton, P., McMurray, I., and Brownlow, C (2004). SPSS Explained; Routledge Taylor & Francis Group: London, UK, pp. 363–364.

HSE (2015) Managing health and safety in construction. Available from www.hse.gov.uk/pubns/priced/l153.pdf. [Accessed 03 September 2020].

Idoro G.I. (2008) Health and safety management efforts as correlates of health and safety performance in the Nigerian construction industry. *Journal of Civil Engineering Management*, 14(4), pp. 277–288.

Idoro G.I. (2011) Comparing occupational health and safety (OHS) management efforts 607 and performance of Nigerian construction contractors. *Journal of Construction in Developing Countrie*, 16(2), pp. 151-173.

Keeter, S., Kennedy, C., Dimock, M., Best, J. and Craighill, P. (2006) Gauging the impact of growing nonresponse on estimates from a national rdd telephone survey. *Public Opinion Quarterly*. 70, pp. 759–779.

Luczak, H., Hinrichsen, S. and Mutze-Niewöhner, S. (2006) Human in Work System Environment. In W.S. Marras and W. Karwowski (eds.) (2006) "The Occupational Ergonomics Handbook" Fundamentals and Assessment Tools for Occupational Ergonomics. 2nd ed., CRC Press, Taylor & Francis Group.

Manu P., Poghosyan A., Mshelia I.M., Iwo S.T., Mahamadu A.M., and Dziekonski K (2018) Design for occupational safety and health of workers in construction in developing countries: A study of architects in Nigeria. *International Journal of Occupational Safety and Ergonomics*. https://www.tandfonline.com/doi/abs/10.1080/10803548.2018.1485992.

National Occupational Safety and Information Centre (NOSHIC) (2006) Nigeria: Report of the National Occupational Safety and Health Information Centre (CIS). Geneva: NOSHIC. Available at https://www.ilo.org/legacy/english/protection/safework/cis/about/mtg2006/pnga_mlpid.pdf. [Accessed 19 February 2020].

Root, D. and Blismas, N.G. (2003) Increasing questionnaire responses from industry: Practices surrounding the use of postal questionnaires. In Proceedings of the 19th Annual ARCOM Conference, Brighton, UK, 3–5 September 2003; Greenwood, D.J., Ed.; Association of Researchers in Construction Management: Reading, UK, 2003; 2, pp. 623–631.

Rwamamara, R., and Holzmann, P. (2007) Reducing the human cost in construction through design. In Nordiska ergonomisällskapet. Paper presented at 39th Nordic Ergonomics Society Conference. Sweden.

Rwamamara, R.A. (2005) The Healthy Construction Workplace: Best Practices for the reduction of WMSDs among Swedish Construction workers. Licentiate Thesis, Luleå Technology University, Sweden.

Rwamamara, R.A. (2007) Risk assessment and analysis of workload in an industrialised construction process. *Construction Information Quarterly*, 9(2), pp. 80-85.

Site Safe (2019) Safety in design in construction: an introduction. Retrieved from: https://www.sitesafe.org.nz/globalassets/guides-and-resources/health-and-safety-guides/safetyindesign inconstructionguide.pdf.

Smallwood, J., (2008) The influence of architectural designers on construction ergonomics. *Journal of the Ergonomics Society of South Africa*, 20 (1), pp. 40–55.

Toole, T.M. and Gambatese, J. (2006) The future of designing for construction safety. Availaible:http://www.designforconstructionsafety.org/Link%20Images/P75%20Future%20of%20DfCS%20toole%20and%20gambatese.doc.

Assessment of Building Standard in Health Care Facilities in Minna, Niger State, Nigeria

Yakubu, R.[a], Sulyman, S.O.[b]; Ohadugha, C.B.[c]
Department of Urban and Regional Planning, Federal University of Technology Minna, Niger state

Abstract:

Health is not just the lack of illness in human body, but the overall state of a being, which involve physiological, psychological and public comfort. It is of dominant significance to man and careful as affluence (Ahmad, 2016). For these reasons, health care centers are important and provided as much as possible to restore sick people health condition. The aim of a healthcare system is to employ healthcare, social and other resources to meet people's needs within a given region. Hospitals are the most complex of building types (Kliment, 2014). Each hospital is comprised of a wide range of services and functional units, such as diagnostic and treatment functions, hospitality functions, and the fundamental inpatient care or bed related functions. For this study, the cross-sectional survey type of design was used, in the form of descriptive and explanatory research. Data required to attain the objective includes physical assessment of the health care facilities, the environment, building type, building condition, number of wards and size of wards. Questionnaires and digital camera were employed in the gathering of the data which was descriptively analyzed also. A total of seventeen (17) private healthcare facilities formed the study population; using a purposive sampling method. The numbers of private healthcare facilities form the population sampled in the area. Minna was sub-divide into four quadrant (A, B, C and D), five private health care facilities were selected from each quadrant. The results shows that Figures 4.1 – 4.8 show the summary of conditions of the foundation, roof, floor, wall, painting, windows, doors, toilet and sewage facilities respectively. It was discovered that 59.3% of the health care facility buildings in Minna have leaking roof, 7.3% have rusty roof, 8% of the roofs are partly ripped off while only 25.3% are in good condition. Finding suggest that despite the satisfactory rating for certain separate aspects of services given by more of the patients in the survey, the overall experience There is need for purpose-driven preventive maintenance culture and underpinning plans/policies as part of a holistic integrated infrastructure delivery process.

Keywords: Healthcare, Building standards, Facilities, Housing Condition, Patient Satisfaction

Introduction

Buildings are required to provide a conducive and safe environment for various human activities. The extent to which buildings provide the required environment for the required activity is a measure of the functionality of the building (Oladapo, 2015). Nous Hospital Consultants (2018) regarded a hospital as not a mere building, but a complex social institution, composed of many groups representing a wide variety of interests and diverse needs that utilise the services of various medical, paramedical and support personnel to render all needed health care to the patients in its custody. It employs a wide variety of modern technologies and engineering services to support the process of healthcare using numerous biological, pharmaceutical, chemical and bio-chemical substances. It handles the dynamics of life and death situations during the process of rendering healthcare. Streifel (2017), described a hospital building as a healing indoor environment needed in healthcare to prevent infection control. Ulrich (2019) described a hospital building to be a healthcare environment that should measurably improve patient outcomes, reduce or eliminate environmental stressors, provide positive distractions, enable social support and give a sense of control. The goal of every health institution is to provide patient care, and produce medical and health manpower.

In furtherance of this goal, staff with expertise of the highest skill are motivated in an environment that is clean, conducive and patient friendly. Hospital buildings are places where care and cure should be available to the public, but due to lack of maintenance public hospital buildings have become a place where people working in the built environment and patients have allergic-like reactions to unspecified stimuli: reactions like dizziness, nausea, irritation of mucous membrane, eye and/or nasopharyngeal irritation and sensitivity to bad odour from human waste, poor toilet facilities, and insufficient cleaning methods.

The awareness for a healthy and comfortable work environment in buildings has not yet taken root or informed the design of healthcare facilities. This is because the pressure to create sustainable buildings has given more attention to the environmental aspects of the built form, and less to the health and wellbeing of occupants. Researchers, however, have begun to understand the need to focus on the sustainable environment for occupants. (Smith and Pitt, 2015) identifies the influence of each factor affecting hospital wards environment and explores its relationship with health recovery, health satisfaction and therapeutic ambience.

Methods

For this study, the cross-sectional survey type of design was used, in the form of descriptive and explanatory research. Data required to attain the objective includes physical assessment of the health care facilities, the environment, building type, building condition, number of wards and size of wards. These variables were sourced primarily and majorly with the aid of checklist and will be descriptively analyzed. Identification of the major building components materials such as wall, window, door, roof, floor and ancillary services as well as their conditions are necessary. Questionnaires and digital camera were employed in the gathering of the data which will be descriptively analyzed also.

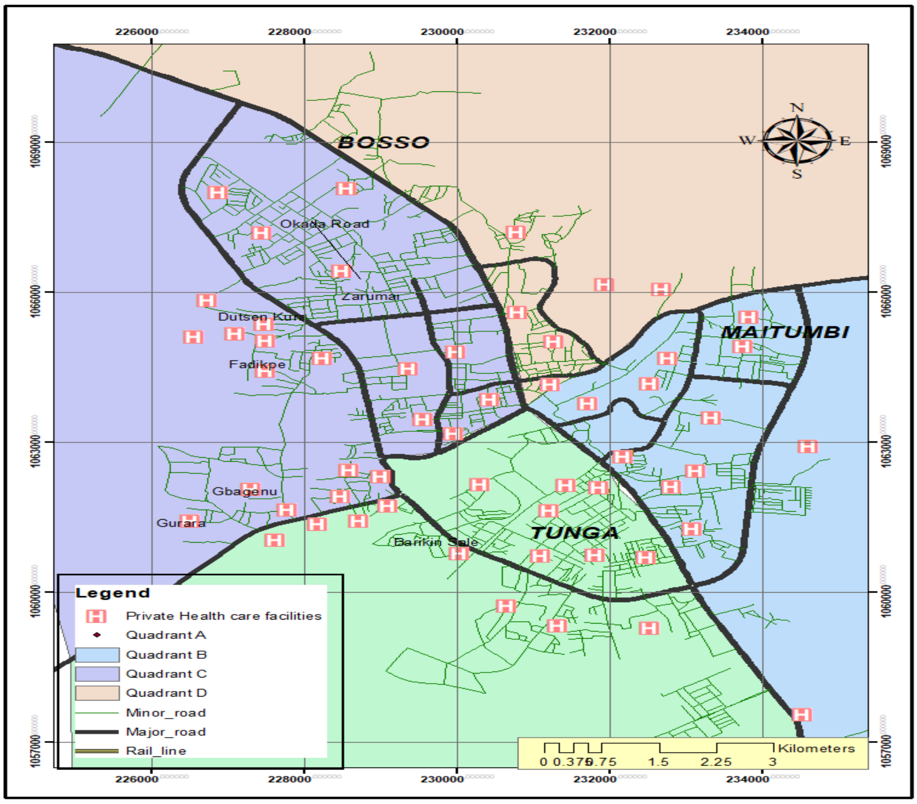


Figure 1: Map of Private Health Facilities in Minna

Results

Physical characteristics of some selected private health care facilities in Minna

The conditions of different parts of the buildings in the selected private health care facilities in Minna are indicative of the overall structural health of the buildings. Figures 4.1 – 4.8 show the summary of conditions of the roof, floor, wall, painting, windows, doors, and toilet and sewage facilities respectively. The roof is a very important part of a building; it shelters the occupants from rain, sun and other environmental effects. From the survey conducted, it was discovered that 59.3% of the health care facility buildings in Minna have leaking roof, 7.3% have rusty roof, 8% of the roofs are partly ripped off while only 25.3% are in good condition. This means that 74.6% of the roofs need urgent attention for maintenance

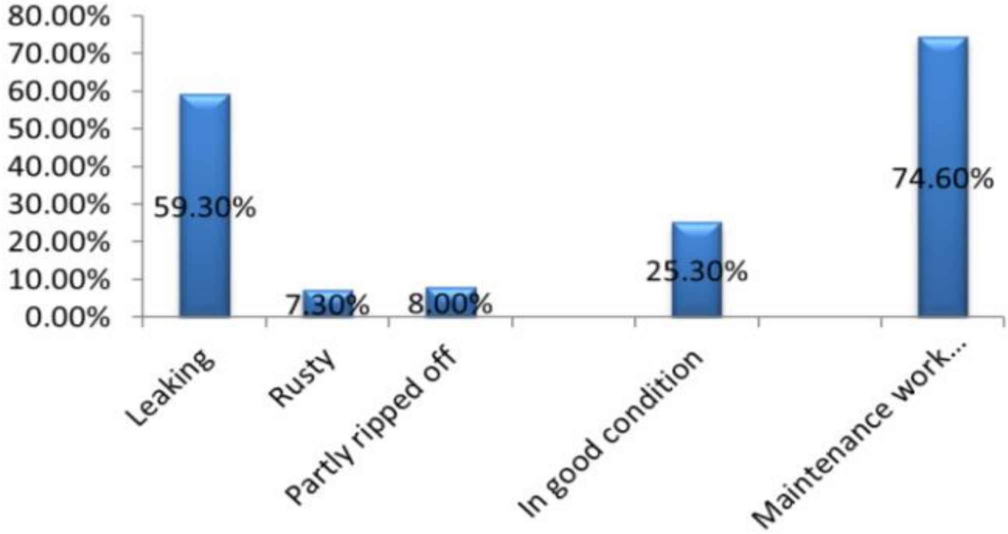


Figure 2: Condition of The Roof of The Health Care Facilities Building

Plate I: Evidence of Leaking Roof in One of The Selected Health Facilities

Floor of the health care facilities building

This is the part of the building that experience the most activity, hospital birds and other heavy equipments are placed on the floor, occupants walk on the floor and heavy moveable loads are stationed to stand on the floor on a particular spot for a long time without repositioning, all these causes wearing of the floor. From the analysis of survey results, 21.3% of the health care facilities buildings have cracked floors, while 36% have peeled off floors, only42.6% had their floors in good condition. This means that 57.3% of the floors in residential buildings are in very bad condition and needs urgent maintenance.

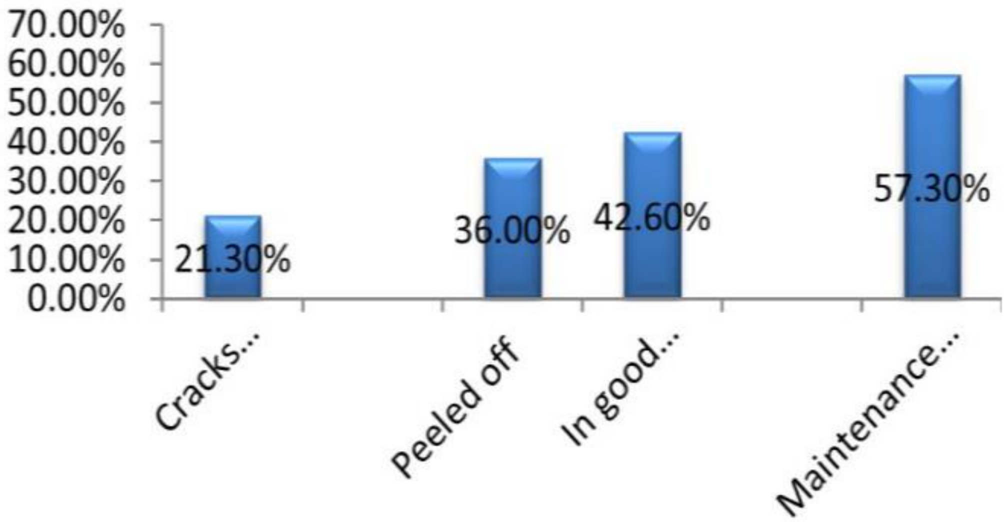


Figure 3: Condition of Floor of The Health Care Facilities Building

Wall of the health care facilities building

This is a very important part of a building; the wall partitions a building and gives the building a meaning. From the survey results 4.3, 4% of the health care buildings have their walls partially broken down, 32% have cracked walls, 24% have peeled off walls, while only 40% have their walls in good condition. This means that 60% of the walls of health care buildings in Minna need maintenance.

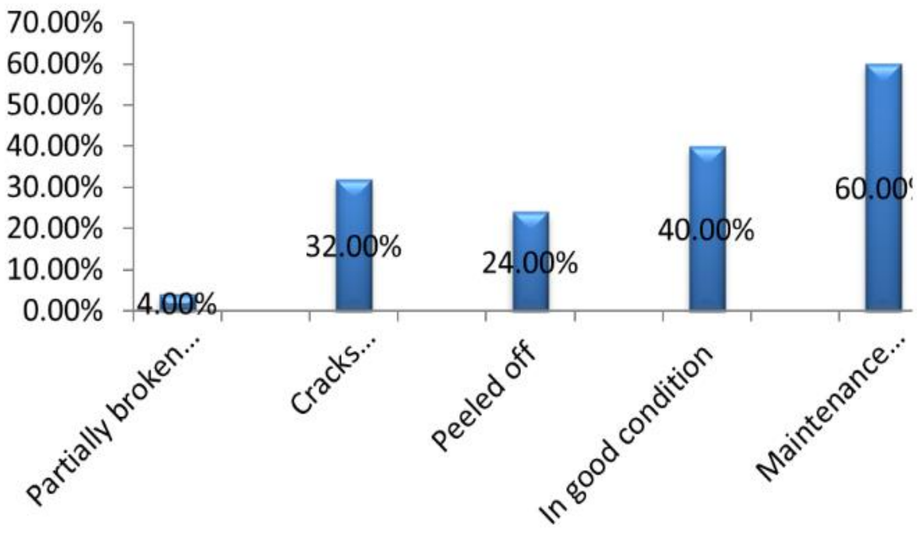


Figure 4: Condition of Wall of The Health Care Facilities Building

4.1.5 Paint of the health care facilities building

Painting adds beauty to a building, and it also helps to protect the building against harsh weather. From analysis of survey conducted in table 4.1, 2% of health care facility building in the Minna have no painting,62% have worn out painting, 7.3% have dirty paint while only 28.6% have their painting still in good condition. This means that 71.3% of the health care facility buildings in Minna need urgent re-painting.

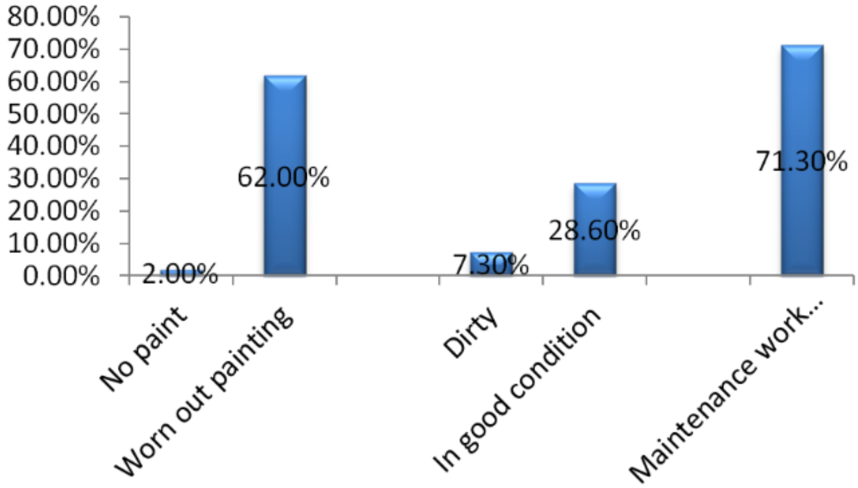


Figure 5: Condition of Pant of The Health Care Facilities Building

Plate III: Evidence of Worn-Out Painting in One of The Selected Health Facilities

Windows of the health care facilities building

This element of a building helps to regulate the amount of air and sunlight that penetrates into a building. From the survey conducted in table 4.2, 14% of the health care buildings have their windows completely broken down, 54.6% have their windows partially broken down, while only 31.3% have their windows still in good condition. This means that 68.6% of the health care buildings surveyed need to have their windows replaced.

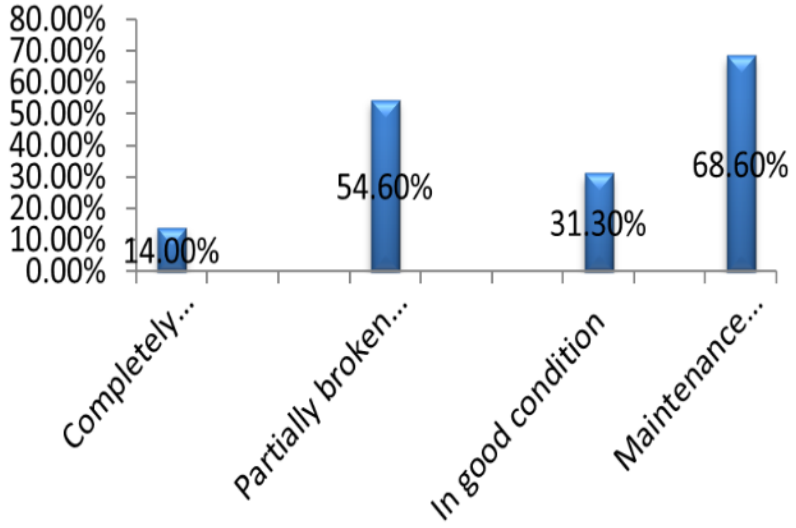


Figure 6: Condition of Window of The Health Care Facilities Building

Figure 7: Evidence of Broken-Down Window in One of The Selected Health Facilities

4.1.8 Toilet Facilities of the health care facilities building

7% of the health care building facility have leaking toilet facilities, 36.8%have partially broken-down toilet facilities, 15.7% have completely broken-down toilet facilities, while only40.3% have their toilet facilities still in good condition. This means that 59.5% of the hostels need their toilets maintained.

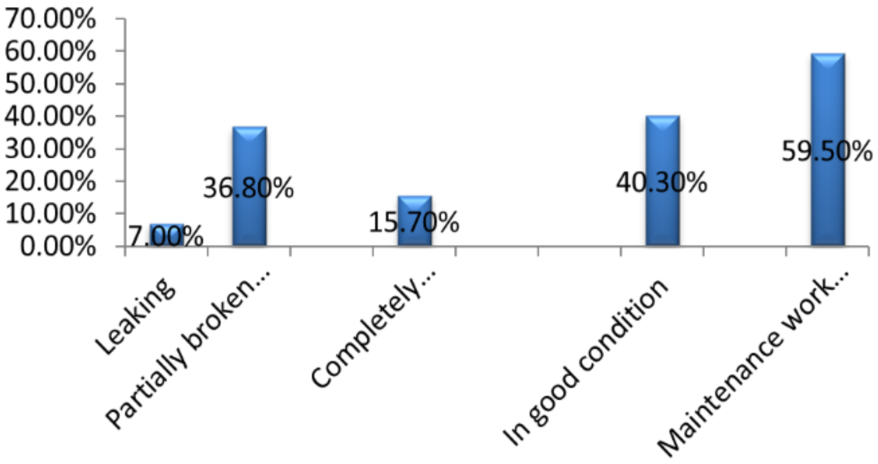


Figure 7: Condition of Toilets Facilities of The Health Care Facilities Building

Plate V: Condition of Toilet Facility in One of The Selected Health Facilities

Conclusions

This research work assesses building standard in private hospital wards in Minna with a view of ascertaining patients' satisfaction. This study found that about 80% of the building in health care facility in Minna requires one or more maintenance work. According to this study, infrastructural maintenance is a big problem in Nigeria. This is because maintenance plans are not integrated into the current project delivery process (i.e., planning, design, construction, operation and use). Poor execution of maintenance work by designated responsible units/agencies, corruption, lack of experienced staff (human capacity building), misuse of facilities by occupants, and poor architectural drawings/designs. There is need for purpose-driven preventive maintenance culture and underpinning plans/policies as part of a holistic integrated infrastructure delivery process.

References

AbouZahr, C. and T. Boerma (2005). "Health information systems: the foundations of public health."Bull World Health Organ **83**(8): 578-583.

Ahmed, A.(2016) Patience satisfaction survey as a tool towards quality improvement. Oman Med Jour.;29(1):3 – 7. https://doi.org/10.5001/omj.2014.02

Dilani, A. (1999) 'Design and care in hospital planning', Unpublished PhD thesis, Sweden: Karolinska Institute

Kiment, S, (2014). Health is a state of complete physical, mental and social well-being and not merely absence of disease or infirmity. Surg Obes Relat Dis.;13(5):887. https://doi.org/10.1016/j. soard. 2017.01.046
Kliment, S. (2000) *Building type, basics for healthcare facilities*, John Wiley and Sons
Nous Hospital Consultants (2002) *Generating the master plan for hospitals*, Leading Hospital and Health Care ManagementConsultants of India
Oladapo, O (2015) Patient-centered healthcare, patient engagement, and health information technology: the perfect storm. In: Grando MA, Rozenblum R, Bates D, editors. Information technology for patient empowerment in healthcare. Germany: De Gruyter; p 3-22.
Smith, R. (2003) 'Best maintenance practices', *Journal for Maintenance and Maintenance Management*, 16(1), 10-15
Streifel, A.J. (2002) *Infection control factors in hospital building maintenance and operation*s, Department of EnvironmentalHealth and Safety, University of Minnesota
Ulrich, R. (1992) 'Garden in health care facilities: uses, therapeutic benefits and design', in proceedings of The Therapeutic Environments Forum, Healing Environments Virtual Seminar.

Factors Affecting Small and Medium Construction Firms Profitability

Aliyu, M.[a] and Ola-awo, A. W.[b]
Department of Quantity Surveying, Federal University of Technology, Minna, Nigeria
alicontact3@gmail.com; olaade4u2006@gmail.com
*Corresponding Author's Email[1]: alicontact3@gmail.com

Abstract

The aim of this study is to investigate factors affecting the profitability of small and medium construction firms in Abuja with a view to proposing strategies to maximise construction firms' profit margins. In a quantitative research design approach, a questionnaire survey was used. The population of the study consisted of construction practitioners (such as procurement officers, accountants, site managers, and directors of the construction organisations) in small and medium construction businesses that registered with the corporate affairs commission in the Federal Capital Territory, Abuja. In Abuja, 224 experienced senior staff were purposefully chosen at random from the organization. The analysis of the data was carried out using descriptive statistics such as the mean item score (MIS). The study revealed that firm size (MIS = 4.34) and firm age (MIS = 4.32) are the most important factors affecting the profit maximisation of the construction firms. The study recommended that in order to improve firms' profitability, more attention should be paid to the following factors: size of firm, age, working capital, and economic environment (firms' profit margins), which are the most significant factors affecting profitability of small and medium construction firms.

Keywords: Factors, Maximizing, Profitability, Small and Medium Construction Firms

Introduction

The construction industry is a major sector of the economy. It contributes significantly to both the (GDP) and Gross Fixed Capital Formation (GFCF) of all nations. A construction project differs from other sector such as manufacturing businesses in that they are cast in situ and they are assembled by various teams of experts (Skibniewski, 2017). In many circumstances, construction projects may be hindered by scarcity in resource allocation and irregular funding, when these are combined with stakeholder requirements, can lead to projects delayed and over budgeted. Therefore, causing negative impacting on the profit maximization of small and medium-sized construction enterprises. Maximization of profit is a very vital objective for a firm to remain in business and to withstand competition from firms operating in similar industries. It is a major pre-requisite for the long-term survival and success of a firm and a key pre-condition for the achievement of other financial goals of a business entity (Gitman & Zutter, 2012).

Profitability is a core measure of the performance of a firm and it constitutes an essential aspect of its financial reporting. It is also referring to the firm's ability to generate earnings at a specific rate of sales, level of assets, and stock of capital in a specific period of time, generating more revenue than expenses, resulting in positive net income (Margaretha & Supartika, 2016). Small and medium enterprises (SMEs) are considered as an independent business that have a small market share and are managed by their owners or part-owners. Although there is no universal definition of a small business, as each nation has its own definition. In the European Union for instance, small and medium-sized firms are non-subsidiary, autonomous organisations with characteristics such as employing less than a certain number of workers (Clair, 2019).

Furthermore, there is a limit to the number of employees engaged by SMEs in various countries across the world. Some countries set the limit at 200 employees. The degree of performance of SMEs is directly related to the management of diverse economic resources and their effective usage within operational, investment, and financing activities (Teshager, 2016).

SMEs employ 92 percent of construction labour force, while large contracting firms accounting for just 8% of the market. Due to, rising market variety of obstacles confronting SMEs, such as poor profit margins and inappropriate capital (Ndulane, 2015). The Nigerian economy has undergone series of reforms since the last one decade under successive democratic governments. However, research efforts towards ascertaining the core determinants of profitability of wide range of firms under these policy reforms have remained sparse. SMEs construction firms have been experiencing the same challenges when measured against the usual criteria of cost, productivity, quality, safety, and environmental responsibility Ofori (2002). Profitability, which is one of the most important pre-conditions for a long-term firm's existence and success, indicates the end result of any commercial activities, and may be diminished if market demand continues to fall. Most small and medium construction firms in Nigeria die within their first five years of existence, a smaller percentage goes into extinction between the sixth and tenth year while only about five to ten percent survive, thrive and grow to maturity (Aremu and Adeyemi, 2011).

The investigation of the factors for maximising the profitability of SMEs construction firms in Abuja Nigeria is apt and expedient. The Nigerian economy has undergone series of reforms since the last one decade under successive democratic governments. SMEs' development in Nigeria is not a one-man affair; all hands must be on deck; the government, individuals and organisations each has to play distinct role towards SMEs development. Etuk *et al.* (2014) notes that for SMEs to thrive, favourable institutional frameworks are required. Unfortunately, their needs are often overlooked by policy-makers and legislators, who tend to target larger corporations.

While a vast number of these studies focused on relatively large firms. To the researchers' understanding, none of these studies focused on the construction sector, especially small and medium firms in the study area. Therefore, this study assessed the factors affecting profitability of small and medium-sized construction firms in Abuja.

Literature Review

Factors that Affect the Profitability of the Small and Medium Construction Firms

The word "profit" has many definitions and is too easily adjusted upward and downward for accounting and taxation purposes. Although you may have done a great deal to increase performance, your success may not show up in accounting profits or profit increases at the end of the year (Cohen, 2009). Because the construction industry is inherently risky, contractors all over the world seek a corresponding profit as compensation for the risks they take (Ajator *et al.*, 2015).

The Oxford Advanced Learners' Dictionary defines profit as money gained in business, especially the difference between the amount earned and the amount spent. In microproject consideration, the sale of products (of a construction project) at a profit depends heavily on how well the managers are able to analyse and interpret supply and demand conditions to control production costs and hold costs down so that prices can be set at a competitive level. For example, to obtain the best machinery, materials, and labour factor at the lowest possible cost in order to maximise profit under given supply conditions (Ajator *et al.*, 2015),

In construction projects, the term "profit" can be defined as the money the project makes after accounting for all costs and expenses. It can also relate to the turnover of the capital employed for each project; hence, the more times a contractor can turnover its capital on a project, the more it affords to cut profit margins. Risk is defined in the standard Learner's Dictionary as the possibility of meeting danger, suffering loss, injury, etc. In project execution, where non-operating income is negligible, the gross operating profit at a given point in time can be determined by evaluating the difference between the total sales and the total costs of sales at that point in time, as follows: Sales revenue minus sales costs equals gross operating profit.

Generally, the gross profit can be forecast by plotting the cumulative effect of sales revenue and production costs in the project time-related "S" curve chart, where the project time duration is scaled along the abscissa and the monetary value is scaled along the ordinate axis. The schedule of project work forms the basis for plotting an "S" curve representing the cumulative effect of sales revenue and cumulative production costs. Construction, like any other business venture, prioritises profitability among their long-term goals because it is an important indicator of business efficiency and on which the business's survival and growth rely. Ajator, Okoye, and Agbonome (2015) stated that profit is a residual. It is the amount of money added to the total estimated cost of labour, material, plant, subcontractor, and overheads of a project (i.e., the direct project cost plus indirect project cost, i.e., overheads and salaries of those not directly working at the site). Profitability is said to be a function of three factors (Wright, 1970);

1) Sales volume (or work done), sometimes called turnover

2) The capital investment necessary to support (1) and

3) The margin of profit earned.

Abebe (2017) identified factors such as effective management of resources, availability of personnel with interpersonal skills as well as project management skills, and proper recordkeeping, whether paper-based or electronic, that should be captured in an entity's recordkeeping system(s) in accordance with the entity's general recordkeeping policies and procedures as factors that impact profit maximisation in any organization. Elibazeth et al. (2020), in their studies on profit maximisation strategies employed by the small and medium-sized building contractors in Dar-es-Salaam, Tanzania, identified that there are numerous factors that affect a construction company's profit margin, i.e., from unexpected delays to unexpected disasters, and these include the following: -time, supply costs, financing, and unanticipated problems. quantity and quality of the firm's resources, Operating leverage, long-term leverage ratio, the firm's position relative to its competitors, Current ratio, short-term, leverage ratio, working capital, age, company growth (opportunities), asset tangibility, size of firm, economic environment (GDP), interest rate, inflation rate, financial inflation rate, and capital structure

Research Methodology

The research design for this study was a quantitative research approach via questionnaire survey. The population of this study comprises senior staff of the construction organisations (such as procurement officers, accountants, site managers, and directors of the construction organisations) in small and medium construction organisations registered with the corporate affairs commission in the Federal Capital Territory, Abuja. According to the Abuja Business Directory (2021), there are 255 small and medium-sized construction firms listed in the Abuja Business Directory with their registered addresses. out of which 244 were randomly selected. This constitutes the target population. At least one senior staff member from each firm in Abuja was purposefully chosen from the 244 senior staff members of the organisations with administrative experience. Table 1 shows the breakdown of the sampled respondents. Data obtained with the aid of a questionnaire was analysed using descriptive statistics such as frequency and mean item score (MIS) with the help of SPSS.

Analysis of Result and Discussion of Findings

The data for the study were gathered using a questionnaire. The questionnaire \were administered to two hundred and twenty (224) respondents and one hundred and fifty- five (155) were retrieved representing a response rate of 69%. This section presents the profile of the respondents considered for data collection. The respondents' profile is presented in Tables 1. Table 1 shows that 54% of the respondents, representing the majority, are first degree holders (bachelor's degrees and higher national diplomas). followed by Master's degree holders, who represent 37% of the respondents. Holders of PhDs, representing the minority of the respondents, constitute 8% of the population of respondents. This demonstrates that the respondents have the basic educational qualifications required to provide reliable responses for the study. Table 1 indicates that 10% of the respondents, representing the minority, have less than five years of experience; 44% of the respondents, representing the majority, have between five and 15 years of experience; 33% of the respondents have between 16 and 25 years of experience; and 14% of the respondents have over 25 years of experience. This shows that the respondents are experienced enough to give reliable information needed for the study. The findings on the positions of the respondents revealed that out of the 155 respondents that filled out the questionnaire, 37 were in procurement, 40 were accountants, 38 were site managers, and 40% were directors. This implies that the survey cut across the stakeholders involved in construction firms' profitability.

Table 1: Presentation of Respondents' Profile

Education attainments	Frequency	Percent
HND/B.Sc.	84	54.2
M.Sc/ Mtech	58	37.4
Ph.D	13	8.4
Total	**155**	**100.0**
Work experience of respondent	**Frequency**	**Percent**
Less than 5 yrs	15	9.7
5 yrs – 15 yrs	68	43.9
16 yrs – 25 yrs	51	32.9
More than 25 yrs	21	13.5
Total	**155**	**100.0**
Position of respondent	**Frequency**	**Percent**
Procurement officers	37	**23.8**
Accountant	40	**25.8**
Site managers	38	**24.6**
Director	40	**25.8**
Total	**155**	**100**

Analysis of Result and Discussion of Findings

The factors that affect the profitability of small and medium construction firms are presented in Table 2. The table presents sixteen (16) identified factors affecting the profitability of construction firms. The respondents agreed that the most important factors affecting the profit maximisation of the construction firm are: The size of the firm was ranked first with a MIS of 4.34, followed by age, which was ranked second with a MIS of 4.32. Working capital and the economic environment (GDP) were ranked third with a MIS of 4.26 and 4.26, respectively. Inflation rate and financial risk were identified as the least-ranked factors affecting construction firm profitability (MIS 3.18 and 3.00, respectively). On average, all of the identified factors influencing construction firms' profit maximisation are important (average MIS = 3.56). Findings from this study are in tandem with findings from Sheikh & Wang (2013), Khan (2012), Dawar (2014), and Salim & Yadaw (2012), which established firm size and a study (Onaolapo & Kajola, 2010; Muritala, 2012; Dawar, 2014) that established firm age as important factors that affect a construction company's profit margin.

Table 2: **Factors Affecting Profitability of the Small and Medium Construction Firms**

Factors	MIS	Rank	Decision
Size of firm	4.34	1st	Agree
Age	4.32	2nd	Agree
Working capital	4.26	3rd	Agree
Economic Environment (GDP)	4.26	3rd	Agree
Company Growth (Opportunities)	3.52	5th	Agree
quantity and quality of the firm's resources	3.48	6th	Somewhat Agree
the firm's position relative to its competitors	3.46	7th	Somewhat Agree
Asset tangibility	3.40	8th	Somewhat Agree
Interest Rate	3.38	9th	Somewhat Agree
Current ratio	3.38	9th	Somewhat Agree
Capital structure	3.35	11th	Somewhat Agree
Operating leverage	3.30	12th	Somewhat Agree
Short-term leverage ratio	3.20	13th	Somewhat Agree
Long-term leverage ratio	3.20	13th	Somewhat Agree
Inflation Rate	3.18	15th	Somewhat Agree
Financial Risk	3.00	16th	Somewhat Agree
Average MIS	***3.56***		***Agree***

Conclusion and Recommendations

Results of the analysis carried out led to the conclusions made in this chapter. Based on the results of this study, the most important factor affecting the profit maximization of the construction firm is firm size. As a result of the conclusions made in this study, the following were recommended: The study suggests that in order to improve firms' profitability, more attention should be paid to the following factors: size of firm, age, working capital, and economic environment (firms' profit margins), which are the most significant factors affecting profitability of small and medium construction firms.

Reference

Abebe, K. (2017). An Assessment of Project Management Competency: The Case of Ethio Telecom. Addis Ababa University.

Ajator, U.O., Okoye C, Agbonome, F.C (2015). Controlling the Mythical Features of Construction Profit. *International Journal of Engineering, Applied and Management Science Paradigms, Vol. 21 Issue 01* Publishing Month February 2015

Aremu, M.A. and Adeyemi, S.L. (2011). Small and medium scale enterprises as a survival strategy for employment generation in Nigeria, *Journal of Sustainable Development*,4(1). 200–206

Clair, A. (2019). *Strategies to increase your construction business revenue.* Available at: https://articles.bplans.com/strategies-to-increaseconstruction- business-revenue/.

Cohen, A.W. (2009). "How to make it big as a Consultant:" Amacom Publisher 4thEdition Pp. 105.

Dawar, V. (2014). Agency theory, capital structure and firm performance: some Indian evidence. *Managerial Finance,* 12(40), 1190-1206.

Elizabeth H. Kyssima, Dennis N.G.A.K. Tesha, Didas S. Lello, & Flaviana S. Mtitu. (2020). Profit Maximization Strategies Employed by the Small and Medium Size Building Contractors in Dar-Es-Salaam, Tanzania. *International Journal of Engineering and Management Research,* 10(1), 92–110. https://doi.org/10.31033/ijemr.10.1.17

Etuk, R.U., Etuk, G.R., & Michael, B. (2014). Small and medium scale enterprises (SMES) and Nigeria's economic development. *Mediterranean Journal of Social Sciences,* 5(7), 656-662.

Gitman, L. J. & Zutter, C. J. (2012), Principles of Managerial Finance, 13th Ned., USA: Addison Wesle,

Khan, A. G. (2012). The relationship of capital structure decisions with firm performane: A study of the engineering sector of Pakistan. *International Journal of Accounting and Finanial Reporting,* 1(2), 245-262.

Margaretha, F. and Supartika, N., (2016). Factors Affecting Profitability of Small-Medium Enterprises (SMEs) Firms Listed in Indonesia Stock Exchange. *Journal of Economics, Business and Management,* 4 (2), 132-137.

Muritala, T. A. (2012). An empirical analysis of capital structure on firms' performance in Nigeria. *International Journal of Advances in Management and Economics,* 5(1), 116-124.

Ndulane. F. (2015). An assessment of challenges contributing to poor performance of small and medium contractors in Tanzania; A case study of Lindi region. *Unpublished MSc. in Accounts and Finance Dissertation, Mzumbe University, Morogoro, Tanzania*, pp. 65.

Ofori G. (2002). Challenges Facing Construction Industries in Southern Africa. Proceedings of Conference on Developing the Constructions Industries of Southern Africa, Pretoria South Africa

Onaolapo, A. A. and Kajola, S.O. (2010). Capital Structure and Firm Performance: Evidence from Nigeria. *European Journal of Economics, Finance and Administrative Sciences.*

Salim, M., & Yadaw, R. (2012). Capital structure and firm performance: Evidence from Malaysia Listed companies. *Procedia- Social and Behavioral Sciences*, 65, 156-166.

Sheikh, N. A., & Wang, Z. (2013). The impact of capital structrure on performance: An empirical study of non – financial listed firms in Pakistan. *International Journal of Comerce and Management,* 4(23), 354-368.

Skibniewski, H.A.A.M. (2017). *Profit maximization and strategic management for construction projects.* Available at: pmsymposium.umd.edu/pm2017/wpconte nt/uploads/sites/3/2017/01/Profit.

Teshager, K.A. (2016). Factors affecting profitability; the case of Ethiopian selected private construction companies. Unpublished MSc. in Accounts and Finance Thesis, School of Graduate Studies, St. Mary's University, Addis Ababa, Ethiopia, 61 Pages