The Role of Effective Information Dissemination in Mitigating the Effects of Fuel Subsidy Removal In Nigeria, With A Focus On Kogi State.

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Abstract

This paper investigates the roles of effective information dissemination in mitigating the effects of fuel subsidy removal in Kogi State. There is a social contract between the government and the people, in a democratic system of government which implies that citizen should be well informed about challenges and the gains of this policy, to avert fake news which can cause chaos, anarchy, and other social vices that are not good for the present democratic dispensation. Fuel subsidy removal came as a shock to Kogi people after listening to the presidential broadcast of president Ashiwaju Bola Ahmed Tinubu, on the 29th May, 2023. Since the discovery of petrol in Oloibiri in the present Bayelsa state, petrol has remained the mainstay of Nigerian economy and any hike in the price of petrol always results in socio-economic hardship to the citizen. It is quite obvious in Kogi state that, since the removal of fuel subsidy, there has been drastic increase in the cost of goods and services, it is therefore necessary to create a better understanding between the government and the people using the strategy of effective information dissemination, because information is power which can clear any form of fake news and rumour mongering in relation to fuel subsidy removal. Data was collected from both primary and secondary sources using both qualitative and quantitative approaches while the samples of two hundred respondents were selected from population of three hundred and thirty-five people. Data obtained from field survey was carefully analyzed to achieve the objective of the study.

KEYWORDS: *Effective Information Dissemination, Fuel Subsidy Removal*.

INTRODUCTION

Historically, the issue of fuel subsidy removal has been a controversial issue, which several governments in the past have attempted to remove subsidy on fuel but Nigerian resisted the policy. (Sunday 2023).

Vice President Kashim Shettima said Nigeria must get rid of fuel subsidy before it deals a deadly blow to the country. He further stated that, the President has issued pronouncements on fuel subsidy, the truth of the matter is that the poor over 80% of Nigerian benefit little. In the year 2022 the government spent $10 billion subsidizing ostentatious lifestyle of upper class of the society, so it is better for subsidy to go.

Since the removal of fuel subsidy through a national broadcast, when President Asiwaju Bola Ahmed Tinubu was sworn in as the 16th President of the Federal Republic of Nigeria on May 29th, 2023, the increase in the price of fuel has invariably results to high price for the consumers. It is quite obvious that the removal of fuel subsidy has brought a lot of hardship to not only Nigerians but other African Countries depending on Nigeria for fuel. The fact remains that fuel subsidy is gone and this is a government policy and economic reality that Nigerian need to cope with.

What is Government Policy?

To Isah (2013) government policy can be regarded as the actions and inactions of the government, it entails what the government want to do, when to do it and how to do it.

In a democratic dispensation, especially in Nigeria, policies cannot be separated from good governance, because government must formulate one policy or the other to improve the standard of living of the citizenry educationally, politically, and socially. For the policy of fuel subsidy removal to have the desired positive effects on Nigerian, it is imperative for Nigerians to be well-informed about this policy. Nigerians need to know what they stand to benefit from the policy in the long run.

In view of the above, the researchers conceived the idea of carrying out this research work on ***"The Role Of Effective Information Dissemination In Mitigating The Effects Of Fuel Subsidy Removal In Nigeria, With A Focus On Kogi State"***.

After the removal of fuel subsidy, there have been series of misinformation from different quarters and such rumour mongering can result to fake news, chaos and anarchy that will cause setback for Nigeria's democratic journey.

Librarians and other information experts in the media houses need to be more proactive in their responsibilities, by providing timely information to Nigerians, because government and governance is a social contract between the leaders and the followers. Through effective information dissemination, Nigerians will be in

a better position to really understand government policies and how to cooperate with the government for the achievement of the goals of the policy of fuel subsidy removal.

Kumar (2017) observed that, the vital activities in the library involves acquisition, collection, processing of information – materials to render information services like Reference services, document delivery, selective dissemination of information etc., all these acts to satisfy the information needs of the readers about full subsidy removal.

Oghenetega (2014) is of the opinion that we are now in the era of Information and Communications Technology (I. C. T.), the use of ICT in the library is becoming more popular especially in academic Libraries in Nigeria. The use of ICT involves online literature searching, and making use of computers to support learning and research (McDonald 2005). With the aid of ICT, Librarians and other library staff stand a better position to disseminate current and relevant information available to information seekers at free cost.

According to Khan (2016) in the olden days, the library was considered as a mere house of knowledge, where some people cannot even differentiate between a library and a bookshop, but with the advent of Information and Communication Technology (ICT) libraries are better positioned to render effective information services to library users and information

seekers. The emergence of ICT in the field of Library and Information Science brought about changes in the way Libraries operate, which enables new forms of Library and Information Services as well as adding value to existing processes and activities, facilitating the service of librarians' interaction with users.

Sutton (2001) observed that the changes brought about by ICT into the Library and Information Services (LIS) profession can be divided into major categories; namely the natural evolutionary change, and on the other hand transformational changes.

Sutton (2001) further added that, with the evolution of information service delivery today, library and information professionals have harnessed the potential of ICT to perform old tasks better and more efficiently, through the digital nature of housekeeping tasks such as reference works, bibliographic services, cataloguing serial control, circulation and acquisition. In this regard, the transformational changes which have occurred include the emergence of new functions arising out of an expanded demand-driven information society, wider interdisciplinary jurisdiction of information services with closer focus on ever-expanding techno-centric user's needs. These informative trends represent systematic changes that substantially alter the boundaries of the Library and Information Sciences (LIS) profession. It has also been noted by Kumar

(2015) that, library now witness the genre of library users who exhibit much dexterity in the use of modern information technologies such as the social media and other collaborative technologies. This generation of information seekers have greater preference for information resources in electronic format, which are available on the internet. The resources can be easily accessed through computers, laptops and mobile devices. As a result, librarians in Kogi State need to take advantage of the new trends in information technology to disseminate needed information to information-seekers as a means of reducing misinformation and fake news that can destabilize peace in our society, the era of post-fuel subsidy removal.

STATEMENT OF PROBLEM

One of the greatest problems that is of concern to the researcher is the evil of fake news and misinformation. If Nigerians are not properly informed about the issues surrounding fuel subsidy removal, it could lead to violence, destruction to lives and property.

Again, Nigeria is one of the largest Countries on the African continents which also occupies a very important position in African politics; that is why there is that belief that, Nigerian is a "big brother" to other smaller African nations. In view of the above, any government policy that could cause social unrest has to be properly managed through information dissemination. As it has been stated before that government and

governance is a social contract between the leaders and the followers, there is need for effective dissemination of information about the plan of government to alleviate the suffering of the people as a result of the removal of fuel subsidy. Due to the large population of Nigeria, which was estimated to be over two hundred million people, the problem is that if there is war in Nigeria over the issue of removal of fuel subsidy, which Country in Africa has such capacity to accommodate refugees from Nigeria? That is a serious problem that the policy-makers should seriously think about, so that Nigerians should be well-informed about the pains and the future gains of removal of fuel subsidy.

It is in view of the above, that researches of this nature should be intensified to proffer solutions to some of the salient issues that could throw the Country into a state of confusion.

JUSTIFICATION OF THE STUDY

This research work is very important to different people and most importantly the general public, because the research work is a good material to policy-makers. In policy circles; like policy formulation, policy implementation, policy analysis and evaluation, the policy makers need to relate the policy of fuel subsidy removal with all these processes, to ascertain if the government has actually taken enough time, in the formulation of this policy, and if the National Assembly has really well in the evaluation

processes, and the effective implementation of the policy. All these processes associated with public policy need to be properly adhered to for the policy of the government to achieve the desired objectives.

Another importance of this research work is that, it deals with contemporary issue that affects Nigerians both poor and rich. All of us in Nigeria cannot do without fuel, the business class, politicians, students, lecturers, doctors all need petrol to survive, because petrol is the mainstay of the Nigerian economy. That is why the Labour Party (LP) has condemned the action of government in removal of fuel subsidy, that the policy was forced on Nigerians without due consultation (Bakare, 2025).

This research work can also serve as reference material to future researchers who may likely have related research work to carry out. The research recommendations at the end of this research work would go a long way to ameliorate some of the challenges associated with the policy of fuel subsidy removal in Nigeria.

Ozili (2023) opined that fuel subsidy removal in Nigeria has been a contentious economic reform, often accompanied by social unrest, inflation and political backlash. Fuel subsidies have long been a financial burden on the Nigerian government, often criticized for being economically unsustainable and disproportionately benefitting the wealthy (Nwokolo, 2022). Their removal, though fiscally prudent, usually results in socio-economic disruption.

Historically, fuel subsidies were introduced to cushion Nigerians against global price volatility. However, they became a drain on the economy, costing the government billions annually (NESG, 2023). The removal of subsidies particularly under the Tinubu administration in 2023 sparked protests and public outcry, underscoring the need for better communication strategies.

RESEARCH OBJECTIVE

Given the nature of the problem under study, "The Role of Effective Information Dissemination in Mitigating the Effect of Fuel Subsidy Removal in Nigeria, A Case Study of Kogi State", the main objective of this research work is to contribute to the development of the nation through a research work geared towards solving contemporary issues affecting the nation. Other objectives of the study are:

a) To embrace fuel subsidy removal policy as a policy in the right direction.

b) To promote effective information dissemination strategies that, can fully inform Nigerians about this policy.

c) To reduce the tendency of rumour mongering as a result of misinformation arising from the policy of fuel subsidy removal.

d) To highlight some palliative measures put in place by Kogi State government to reduce the effects of suffering of the people.

RESEARCH QUESTION

To achieve the purpose of carrying out this research work, these research questions emanated from the objectives as follows:

1) Is the removal of fuel subsidy a policy in the right direction?

2) Is the Nigerian populace well-informed about the pains and gains of this policy?

3) Can misinformation about the policy of fuel subsidy removal cause social unrest, chaos and anarchy?

4) Is it necessary for the government to roll out some palliative measures to cushion the effects of this policy?

5) Can effective information dissemination help Kogi people to really cooperate with the government?

SCOPE OF THE STUDY

This aspect of the research explains the coverage of the research work. The research is basically on "The Role of Effective Information Dissemination in Mitigating the Effects of Fuel Subsidy Removal in Nigeria with A Focus on Kogi State Government". The research work covers six months from June-December, 2025.

Within the time of the study, the researcher intends to collect data from the respondents and all those relevant stakeholders in the State, to get adequate information on the subject matter of the research work.

CLARIFICATION OF CONCEPT

Fuel Subsidy Removal

Fuel subsidy is the amount the government has been paying to augment the amount consumers are paying for fuel.

Effective Information Dissemination

In the contest of this write up, effective information dissemination connotes the free flow of information from government, the media and other relevant stake holders in the implementation of fuel subsidy removal policy to the people so that Kogi people will not be misinformed about t the policy.

To Ebijuwa (2005) information dissemination as the processes and techniques of sharing and sending information to the target audience. Raganathan Library Rule (3) states that "Every Book. Its Reader and every person, his or her own book". This golden rules from Raganathan illustrated the fact that, library is meant to provide information to information users.

Oni (2002) believed that, the world, especially developing nations believed that information is power, because we are in the era of information revolution. This is the period Nigeria and other

developing economies have accepted information as valuable resources equitable to natural resources like gold, petrol, coffee etc. Information dissemination techniques are all the means of making information more accessible to the information seekers, such information can only make the needed impact in the life of the people when it is effectively disseminated.

LITERATURE REVIEW

FUEL SUBSIDY REMOVAL AS A GOVERNMENT POLICY

According to Johnson (2023) in a report by Price Waterhouse Cooper (PWC) in Nigeria titled "Fuel Subsidy in Nigeria, Issue Challenges and the Way Forward", the price of petrol was increased by subsidy removal policy of President Asiwaju Bola Tinubu immediately the President was sworn in as the 16th President of Federal Republic of Nigeria on May 29th, 2023.

The announcement of this policy was described by Johnson (2023) as "sudden and unexpected" as it was done without the President discussion with the relevant stakeholders. To him, the policy was not new, because President Goodluck Jonathan attempted to remove fuel subsidy but sparked a lot of criticism.

Muyideen (2023) reported that, President Ahmed Bola Tinubu declared that "fuel subsidy is gone". He said, in the President's inaugural speech, the President commended the decision of former President Muhammadu Buhari to phase out petrol subsidy regime which he said, had increasingly favoured the rich over the poor.

Tinubu said the subsidy can no longer justify its ever-increasing costs in the wake of drying resources. The President opined that "we shall re-channel the fund to better investment in the public infrastructures, education, healthcare and job creation that will improve the lives of millions of Nigerians".

On fuel subsidy removal, Abass (2023) observed that "there will be more revenue for the government an unlocking of about 7 trillion Naira into the Federation Account while reducing the fiscal deficit". The subsidy removal will also eliminate economic distortions and stimulate investment. We would see more private investments in private refineries, petrochemicals and fertilizer plants.

To Idowu (2023) the post-subsidy regime would also unlock investments in pipelines, storage facilities, transportation and retail outlets. He further opined that, "smuggling of petroleum product across the borders will come to an end with the market pricing of refined products. It is important to put an end to NNPC monopoly in the supply of petroleum products. Competition is imperative for subsidy removal to be sustainable".

In line with fuel subsidy removal issue, Idowu (2023) further stated that, the leadership of Petroleum and Natural Gas Workers

(NUPENG), urged President Tinubu to implement the Petroleum Industry Act (PIA) signed by his predecessor into law to achieve the objective of having a petroleum industry that will be accountable, rewarding and transparent in financials, governance and responsiveness to the needs and the yearnings of communities and stakeholders.

Abubakar (2023) opined that the policy of fuel subsidy removal was a good one, but since this policy is going to affect Nigerians, the National Assembly and the House of Representatives should have discussed this policy before the implementation. One thing is to formulate a policy another thing is for that policy to solve societal problems.

Dr. Abubakar Umaru Kari, an Associate Professor of Political Sociology, University of Abuja said the speech of President Tinubu shows rare intent and resolve to take tough decision on fuel subsidy as well as unity and inviolability of the sovereignty of Nigeria. He further added that, "for me it was a good speech: lucid, loaded and replete with key pronouncements, including a few strong policy ramifications but which could also shock and awe".

Johnson (2023) further discovered that, since the discovery of crude oil in Oloibiri, Bayelsa State in 1956, petrol has remained the mainstay of our economy. Any increase in the price of petrol has tremendous impact on all the sectors of the Nigerian economy. To him diversification of Nigeria's economy from fuel (petrol) to other sectors, like investing more in agriculture, solid mineral, tourism will increase the rate of economic development, as the removal of fuel subsidy may result to increase in poverty and economic hardship.

According to Audu and Ehoniyotan (2011) "information is power". It means that, this era of post-fuel subsidy removal, Nigerians, especially Kogi citizens need more information about fuel subsidy removal. Citizens need to be adequately informed about policy that affects their lives directly. The unstable electricity supply has been a serious problem in Nigeria which has been affecting the industrial sector, that most companies now use petrol and diesel engines to power the companies. Removal of fuel subsidy coupled with epileptic power supply can worsen energy crisis in Nigeria.

The Role of Effective Information Dissemination In Mitigating The Effects Of Fuel Subsidy Removal In Nigeria

Effective dissemination of information is defined here as the strategic, transparent, and inclusive communication of government policy and how it can significantly mitigate these negative impacts. These roles are stated as follows:

1. Public Awareness and Education

   Public Awareness campaigns that explain economic benefits, address misconceptions, and clarify the governments intentions can reduce resistance (Punch, 2023).

2. Stakeholder Engagement

   Engaging civil society organizations, labour unions, and local leaders allows the government to tailor messages and incorporate feedback (Guardian, 2023).

3. Media Strategy

   The media plays a central role in shaping public opinion. Messages must be delivered in local languages and cultural contexts (Academia et at, 2023).

4. Transparency and Trust Building

   Providing data on how subsidy savings are reinvested builds public trust. The people would like to know how and what the money saved from subsidy removal is utilized, so as to build trust in the government (Premium Times, 2024).

5. Combating Misinformation

   A responsive and accurate communication system counters false narratives effectively. There should be a regular, prompt and free flow of information and communication from the government (Academia edu, 2023).

6. Complementary Communication with Social Policies

   Dissemination must be coupled with information about social safety nets like conditional cash transfers. Awareness of these measures can prevent social unrest and support vulnerable populations (NESG, 2023).

Challenges in Dissemination

Dissemination efforts face challenges such as low public trust in government, digital illiteracy and language diversity. Overcoming these challenges requires institutional capacity building and partnerships (Brand-Crunch, 2020). Effective dissemination of information is not merely a supplementary activity in subsidy reform, it is central to its

success. The Nigerian government must adopt an inclusive, transparent and strategic communication approach to ease the transition from fuel subsidy and achieve long-term development goals.

Mitigating the Effect Of Fuel Subsidy Removal Through Effective Information Dissemination

As observed by Raifu & Afolabi (2024), the following are suggested ways of mitigating the effect of fuel subsidy removal through effective information dissemination:

1. Transparent Communication of Rationale

   Clarify why subsidies were removed, using relatable terms and data. For transparency's sake and avoidance of doubt and suspicion, unnecessary jargons should be avoided and evidence on how savings are reinvested be provided.

2. Multi-Channel Information Campaigns

   Use traditional media (radio, TV), digital platforms (Facebook, WhatsApp), and community for a to ensure inclusive messaging to the entire populace.

3. Highlight Tangible Benefits

   Publicize reinvestments of saved funds in visible projects. Share citizen success stories to build trust and buy-in. People want to know and hear what the saved funds are being used for.

4. Engage Influencers and Local Leaders

   Partner with traditional rulers, religious leaders, and influencers. Train youth leaders and NGOs for grassroots outreach.

5. Establish Feedback and Support Channels

   Create toll-free lines and apps for questions and grievances. Monitor feedback to adapt messaging strategies.

6. Counter Misinformation Rapidly

   Deploy rapid response teams and fact-checking alliances to tackle false narratives and prevent panic or unrest.

7. Long-Term Public Education

   Incorporate economic policy literacy in civic education and mass media programs. Use creative formats like comics or radio plays to provide entertaining and educative programmes.

Policy Formulation and Implementation

Ojuola (2006) opined that, when we talk of policy process, it means the various ways in which public policy are formulated. The subject matter of public policy varies, as such, approaches to their formulation differs. To this author, it does not matter which institution is responsible for policy formulation and implementation, but the concern is:

i.   What is the policy about?

ii. For what reason?

iii. How was it determined?

iv. What determines the policy options?

v. Who are people involved?

vi. Can the policy succeed in goal attainment? If no, why? If yes, how do we improve the quality of the policy?

It is from the above perspectives that the researcher wishes to evaluate fuel subsidy removal policy. Any public policy can be made in any political system. That is that government has the right to formulate public policy into any political system, be it democracy, dictatorship, autocracy, military, aristocracy or any other system at all (Ayinde, 2006).

To Mahajan (2019) policy is viewed as the action of the government and public policy can be broken into categories of sequential pattern, the process are:

PROBLEM SELECTION – We can ask questions: What are the issues? How does it get into the agenda of the government? They are those problems among many which receive the serious attention of the officials. They are those problems which are made to know to the government for consideration.

Efficacy of Effective Policy Implementation

Ayinde (2006) added that, the importance and the significance of any policy can be determined by policy implementation. The policy implementation stage is also very important, because it is the stage where the actions of the government manifest in form of infrastructural project, rules, laws, regulation etc. To really understand policy implementation, these important questions should be asked:

i. Who is involved?

ii. How do we apply the policy to solve societal problems or the particular problem?

iii. Does the people involved have the qualification and capacity to do a good job?

He further added that, before now, scholars of public policy are of the opinion that once a good policy is formulated, its implementation could not be problematic. It has now been discovered that the major problem confronting public policy is implementation.

In line with the above, the researchers observed that, the removal of fuel subsidy has increased the level of poverty, increase in the cost of living, making life really unbearable to an average Nigerian. In any country why poverty is on the increase, there would be challenges of underdevelopment, insecurity and low level of life expectancy.

Concept of Information Dissemination

To Ebijuwa (2005) information dissemination as the processes and techniques of sharing and sending information to the target audience. Raganathan Library Rule (3) states that "Every Book. Its Reader and every person, his or her own book". This golden rules from Raganathan illustrated the fact that, library is meant to provide information to information users.

Oni (2002) believed that, the world, especially developing nations believed that information is power, because we are in the era of information revolution. This is the period Nigeria and other developing economies have accepted information as valuable resources equitable to natural resources like gold, petrol, coffee etc. Information dissemination techniques are all the means of making information more accessible to the information seekers, such information can only make the needed impact in the life of the people when it is effectively disseminated.

In view of the above, Kogi citizens need adequate information to really appreciate the efforts of the present government at State and National levels, in their efforts to provide the necessary palliatives that can cushion the effects of the hardship created by the policy of fuel subsidy removal. Fagbola (2011) opined that, libraries, especially academic libraries, have very important roles to play in dissemination of most recent information to the people through its current awareness services and strategies; so that

Nigerians can be well informed about the intentions of government on the policy of fuel subsidy removal. This is very important in the sense that, Nigeria is one of the largest countries on the African Continent that occupies a very important position in African politics. There is that belief that Nigeria is a "big brother" to other smaller African countries, and if there is economic crises in Nigeria as a result of the removal of fuel subsidy, which country in Africa has the capacity to absorb Nigerian refugees? The population of Nigeria has been estimated to be above two hundred million people, which shows that no African country can cope with refugees from the large population. Researchers, policy-makers, librarians, information experts and other meaningful Nigerians should then provide adequate information that can move this country forward in this era of post-fuel subsidy removal.

Theoretical Framework

This study is based on Competitive Economic Theory Model. This model promotes sustained rate of productivity which is able to drive economic growth and consequently increase income and welfare at long run. Before the implementation of fuel subsidy removal policy, government believed that payment of subsidy has become an economic burden on government for over a long period of time and subsidy has it were has no really benefited the common man but the few privileged Nigerian.

It is based on these premises that the president decided to call a spade a spade, by putting an end to fuel subsidy and also allow the private sector to do the fuel business while government provides the regulatory framework.

Methodology of The Study

This involves the procedures for analyzing the raw data obtained through field survey. The procedure used in analyzing of the data involves the use of tables, frequencies, percentages, ranking which would be done statistically.

Agba and Adamu (2015) stated that the objectives of the research work cannot be achieved without the analysis of research data.

Primary Method

This involves the collection of data from the main sources through use of research tools like questionnaires, observation techniques and personal interaction with the respondents.

Secondary Method

This also involves the use of documented sources of information, and other secondary data relevant to the write up

DATA ANALYSIS

This involves the procedures for analyzing the raw data obtained through field survey. The procedure used in analyzing of the data involves the use of tables, frequencies, percentages, ranking which would be done statistically.

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Discussion of Findings

From the analysis of data obtained from the research questionnaires, the researchers discovered some findings.

It was discovered from even the comments made by respondents and some articles published on the pages of newspapers in Nigeria, that fuel subsidy removal was actually a policy in the right direction, because of the economic wastage associated with the politics of fuel subsidy. It was also discovered that, the policy has great implications on the socio-economic wellbeing of Nigeria, especially in Kogi State.

Most of the respondents agreed that the news about fuel subsidy removal was sudden alarming and unexpected, because Nigerians are already in hardship from and waiting for President Tinubu to ease the suffering but the reverse was the case.

The researchers also discovered that, the news about fuel subsidy removal spread to all States of the Federation, through radio, television, social media etc., which shows that most Nigerians received the news with shock, immediately after the inaugural speech of Mr. President on May 29, 2023.

Contribution To Knowledge

This study adds value to existing knowledge and researches on this subject matter. Apart from the immense contribution of the study to knowledge advancement, the study is also tailored towards addressing contemporary socio-economic challenges faced by Kogi people as a result of fuel subsidy removal.

The pains and the hardship of fuel subsidy removal is not just a challenge but an issue of national interest that deserve more researches to proffer solution to this national problem.

Conclusion

In conclusion, an important policy of fuel subsidy removal, should have been adequately discussed by the States, National Assembly and other relevant stakeholders, to look at the challenges, advantages and the way forward, but since this was not done by the government before the announcement of the policy, the best way to ameliorate the implications on the citizens, is to carry the people along through effective information dissemination strategy to assure the people that government palliative measures to cushion the effects of this present hardship created by implementation of government policy.

In this present democratic dispensation, people should be well informed about how the policy of government promotes good governance. As long as the researchers have stated it in the Literature Review that government is a social contract between the leaders and the subjects, so efforts should be intensified so the citizens know the future benefits of fuel subsidy removal, in the areas of education, health, security, infrastructural development etc.

Recommendations

As we all know that the removal of fuel subsidy is a policy that has created some socio-economic challenges that Nigerians need to cope with, it is a contemporary challenge that demands solutions. As part of the contribution of the researchers in providing the way forward, these recommendations are put forward:

1. Government should be more transparent in the area of adequate information dissemination, as a means of letting people know the strategies of government in easing the pains of fuel subsidy removal.

2. As a matter of policy there should be prudent accounting systems in the management of the revenue generated from the policy, such accounts should be known so that stakeholders can really know that, there would be gains after all the economic hardship.

3. Palliative measures should be put in place in all States and Local Government Areas to reduce the suffering of the people.

4. Such palliative measures should not be meant for civil servants alone, or the politicians, but for the common people, especially the vulnerable groups.

5. Government at all levels should enhance maximum productivity in agriculture to ensure food security, as the removal of fuel subsidy has taken food out of the reach of the poor.

6. Citizens should also understand the fact that they need to cut down their luxuries, to cope with the present economic hardship occasioned by the removal of fuel subsidy.

7. The citizens need adequate security, through the proceeds of fuel subsidy removal, efforts should be made to improve the security of the citizens, and reduce the present rate of armed robbery, kidnapping etc.

8. Since the price of fuel is on the high side, there is need to reduce power failure so that industries depending on fuel can fall back to electrical energy.

9. As a means of carrying citizens along, more programmes and discussions should be on our radio and television stations to update citizens about the way forward.

10. In this post-fuel subsidy removal era, more roads should be prepared, more infrastructure provided as a means of raising the standard of living of Nigerians.

11. More educational facilities should be provided at all levels from the proceeds of fuel subsidy removal.

12. Health is wealth! Efforts should be intensified by the health sector to improve healthcare delivery services, to reduce self-medication killing Nigerians as a result of their inability to pay for hospital bills and medication.

13. Because the policy of fuel subsidy removal affects almost all the citizens; the researchers also recommend further research in this direction.

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Metal Contamination and Health Risks In Raw Milk From Lokoja Metropolis, Kogi State, Nigeria.

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Abstract

The pressures of population growth, urbanization, and industrialization have intensified environmental pollution, with heavy metals emerging as major foodborne contaminants of public health concern. This study investigated the concentration of copper (Cu), iron (Fe), lead (Pb), cadmium (Cd), chromium (Cr), and zinc (Zn) in raw cow milk obtained from dairy Fulani hawkers in Felele, Lokoja, and surrounding areas of Kogi State, Nigeria. A total of 50 samples were collected between March and August 2024, digested using the standard wet acid digestion method, and analyzed by Atomic Absorption Spectrophotometry (AAS). The results showed that Pb concentrations (0.043–0.411 mg·L^{-1}) exceeded the Codex/FAO-WHO permissible limit of 0.02 mg·L^{-1} across all sampling locations, indicating significant health risks. Cd levels (0.011–0.053 mg·L^{-1}) were similarly high, especially in Igbonla, while Fe concentrations (1.01–2.10 mg·L^{-1}) were above expected background values, suggesting contamination from feed, water, or metallic equipment. Cr levels were generally low but reached 0.177 mg·L^{-1} at the Felele bus stop, likely reflecting anthropogenic activities such as traffic and mechanical workshops. By contrast, Cu (0.015–0.115 mg·L^{-1}) and Zn (0.201–0.821 mg·L^{-1}) were within acceptable ranges and posed no immediate regulatory concern. Health risk assessment revealed that the Target Hazard Quotient (THQ) for Pb and Cd approached or exceeded safe thresholds, suggesting potential non-carcinogenic risks, particularly for children and other vulnerable populations. The findings identify Pb and Cd as the primary contaminants of concern in raw milk from the study area. Continuous monitoring, source-control strategies, and stricter regulatory enforcement are strongly recommended to safeguard public health.

Keywords: Heavy metals, Milk contamination, Public health, Lead, Cadmium.

1.0 Introduction:

With the rise in population, industrialization, and urbanization, numerous pollutants have been released into the environment. Among them, heavy metals such as chromium (Cr), copper (Cu), cadmium (Cd), iron (Fe), Zinc (Zn) and lead (Pb) have become widely dispersed, increasing their likelihood of entering the human food chain (Kwon et al., 2017; González-Montaña et al., 2012). These heavy metals pose significant health risks to both livestock (Rahimi, 2013; Norouzirad et al., 2018) and humans (Perween, 2015), as they are highly toxic even at low concentrations, leading to hematologic, neurotoxic, and nephrotoxic effects. Certain organs are negatively impacted by human exposure to these metals, which can also cause cancer, heart failure, exhaustion, and metabolic problems (Norouzirad et al., 2018; EFSA, 2010; Panel & Chain, 2009; EFSA, 2012). Due to their developing immune systems and different gastrointestinal absorption processes from adults, children are especially affected by this problem (Su et al., 2020). Hexavalent chromium (Cr VI), arsenic (As), and cadmium (Cd) are all categorized as Group 1 carcinogens by the International Agency for Research on Cancer (WHO/IARC, 2020), whereas inorganic lead (Pb) is categorized as Group 2A. According to their prevalence, toxicity, and potential for human exposure, arsenic, lead, cadmium, and chromium were classified as the most dangerous food contaminants in the United States by the Agency for Toxic Substances and Disease Registry (ATSDR, 2019).

Milk, a natural product secreted by the mammary glands of mammals, is widely consumed to meet human nutritional requirements. Owing to its rich composition, it serves as an essential source of nourishment that supports health, cognitive development, and overall growth, particularly in children (Krismaningrum & Rahmadhia, 2020).For instance, fresh cow milk is a kind of milk that is often consumed by the public. This is because besides being easy to obtain and having high nutritional content, fresh cow's milk is also relatively affordable. In a study conducted by Umar et al. (2021), cow milk was reported to be a rich source of protein, fat, carbohydrates, minerals, and vitamins. The overall quality of food and food ingredients in nature cannot be separated from various influences, such as environmental conditions which are the benchmark needed for food to obtain eligibility for consumption (Rahma et al., 2021). The ultimate quality of milk will decrease if there are contaminants in it. Raw milk can be contaminated with heavy metals from the environment, such as Cr, As, Hg, Pb, and Cd. Milk contamination can be caused by several things, such as microbes, pesticide residues, and heavy metals accumulation. Research by Pilarczyk et al. (2023) reported

that consuming meat and milk from heavy metal-contaminated environments is very dangerous for the consumers. Heavy metal contamination of the animal can occur due to organic rearing because heavy metals can come from feed or drinking water that contains a lot of heavy metals. One of the animal-based food ingredients that contain a good nutritional value for human consumption is milk (Arini & Ifalahma, 2021). Mammalian milk has quite a potential opportunity in product development. Milk is popular with the wider community because of its beneficial nutritional content. Fresh raw milk is a liquid produced from the udders of healthy and clean animals from proper milking; its natural content is still pure without being reduced or adulterated with anything. Foodstuffs must be free from the possibility of biological, chemical, and other contamination that can interfere with, harm, and threaten human health, and do not conflict with religion, beliefs, or community customs, so they are suitable and safe for consumption (Hartajanie et al., 2022).

Heavy metals are often described as metallic and metalloid chemical components with high atomic weights and specific gravity, which can be toxic to living things. Heavy metals such as cadmium (Cd), mercury (Hg) and lead (Pb) are not essential elements and have no biological role, but at very low concentrations they can cause toxic effects (Varol & Sünbül, 2020).

Heavy metals can enter foods such as milk and processed products and bioaccumulate in vital organs causing disturbances in kidney function, anemia, the reproductive system, and the nervous system (Silalahi & Purwanti, 2021; Rislamia, 2022). Immense environmental pollution has elevated the problems of milk contamination and uncertainties about milk qualities (Farid & Baloch, 2022). The worldwide milk contamination through environmental pollutants and xenobiotic compounds via cattle feeds like toxic metals, mycotoxin, dioxin and other pollutants are considered to have tremendous influence on public health (Seyed & Ebrahim, 2022). Intake of these contaminated milk acts like an additional source of heavy metal exposure (Ruqia et al., 2020). The main sources of metal contamination are industrial or domestic effluents, combustion, bushfires, decomposition of chemical fertilizers, pesticides, etc. (Degnon et al., 2022). Overexposure of humans to heavy metals could lead to abdominal pain, hepatotoxicity, neurotoxicity, vomiting (Hussain et al., 2020), decreased intelligence quotient (IQ) level, Alzheimer's disease, behavioral disorders (Ahmad et al., 2021), tissue injury, irritation of lungs, cancer (Bushra et al., 2024), etc. Furthermore, heavy metals are known to be highly resistant to bacteria and environmental degradation in nature and become accumulated in the food chains via

biotransformation, bioaccumulation, and biomagnification (Aslam et al., 2021). Complete elimination or prevention of chemical contaminants cannot be achieved from raw milk because the lipophilic contaminants will always find their way into the persistent fat compounds from where heavy metals cannot be readily removed (Girma et al., 2024). The contamination of foodstuffs due to metals and other environmental pollutants is one of the most important issues in developing countries. Several studies have been conducted around the world with reference to the health risks of metals in environmental matrices, for example, arsenic in cultivated rice in Sri Lanka (Channa et al., 2020), trace metal and aflatoxin in cassava flour in West Africa (Hayford et al., 2021), metals-contaminated mushrooms in Ethiopia (Medhanye et al., 2022), health risks for contamination of foods and soils in China (Khan et al., 2023), and India (Sridhara et al., 2023). However, it was observed that continuous long-term exposures of consumers to heavy metals through the consumption of raw milk get less emphasis in developing countries, particularly in Nigeria. Considering the aforementioned challenges in terms of public health hazard of Nigerians, this study was carried out to investigate the concentration of selected heavy metals contaminating raw milks in Felele and Crusher areas, Lokoja, Kogi State. The results from this study are expected to provide baseline information on the level of pollution in this catchment.

2.0 Materials and methods

2.1 Collection of Samples

A total of 50 samples of raw milk of cow were collected from March 2024 to August 2024 from various dairy Fulani hawkers in Felele, Lokoja and environs, Kogi State, Nigeria. All samples were collected in nitric acid-washed polyethylene containers. The samples were immediately transported to the laboratory in a cooler with crushed ice packs and were stored in deep freezers at -20 °C prior to analysis.

2.2 Sample Preparation

All the laboratory glassware and working surfaces were washed well with deionized water and diluted HNO_3 (10%), then rinsed with deionized water followed by drying. The digestion vessels were soaked in water and detergent for about 3 hours with subsequent several rinsing with distilled water and then with a mixture of 80 ml H_2O_2, 200 ml HCl (37%), and 250 ml of deionized water, and again one more time with 10% diluted HNO_3. Finally, all the equipment were washed at least three times using deionized water and air-dried (Sallam et al., 2019)

2.3 Samples Digestion

The samples were digested by the wet acid

digestion technique according to the method reported by Sallam et al. (2019). Two ml of the raw milk samples were homogenized well and transferred quantitatively to a 20-ml screw-capped tube containing 10 ml HNO_3 (97%) and 30 ml HCl and heated at 53 °C in a water bath until complete digestion, followed by cooling at room temperature. After cooling, the digested mixture was placed in a 50 ml volumetric flask containing distilled water to be diluted and then filtrated using Whatman filter paper (No. 42, Merck, Darmstadt, Germany) into clean Pyrex glass tubes and kept at room temperature (35 °C) until analysis for their metals content (Hg, As, Pb, Cd, Cr and Cu) (Sallam et al., 2019). Standard or blank solutions were also prepared in the same manner as the wet digestion technique but without adding any sample. The blank solutions were analyzed to determine any contamination of the chemicals with heavy metals and to be subtracted from the final results.

2.4 Heavy Metals Analysis

Collected filtrates were analyzed for their mercury, arsenic, lead, cadmium, chromium, and copper at the Central Laboratory, School of applied Sciences, Kogi state polytechnic Lokoja,. Heavy metals analysis was carried out with the use of an Atomic Absorption Spectrophotometer (AAS; Buck scientific 210 VGP, Inc.), Iron, Lead, Cadmium, Copper,

and Chromium were determined by air acetylene flow flame AAS (Sallam et al., 2019).

2.5 Health Risk Assessment

The EDI and THQ of heavy metals were calculated to appreciate the non-carcinogenic risks associated with the consumption of heavy metals in dairies. The EDI was calculated according to Eq. (2).

$$EDI = \frac{C \times D \text{ mg/kg bw / day}}{BW}$$

Where, C = the mean concentration of heavy metals in raw milk samples (mg/kg),

D= dairy intake is the daily consumption of milk for each kg BW of an adult person,

While BW = average body weight for an adult person = 70 kg. The average daily consumption per adult person was recorded to be 58.97 mL/g of milk (FAO. 2023).

The THQ was affirmed by the Environmental Protection Agency (EPA) in the USA to determine the non-carcinogenic health risks linked to the consumption of heavy metal-contaminated food, frequency and duration of metal, body weight, and other parameters (USEPA. 2019).

The THQ was calculated according to Eq. (3).

$$THQ = \frac{EDI}{RfD} \quad (3)$$

where, RfD is the reference doses (mg/kg/day) = 0.0001, 0.001, 1.5, 0.04 (mg/kg/day) for Hg (MeHg), Cd, Cr, and Cu, respectively (USEPA. 2019). If the results

of THQ are more than 1, it indicates that the risks of non-carcinogenic potential hazards for human health may occur, but if THQ is less than 1, there won't be any health risk. Yet, if the individual THQ is less than 1, the non-carcinogenic adverse hazards might happen due to the cumulative effect of such heavy elements.

3.0 Results:

3.1 Average Concentration of Heavy Metals in Cow Milk (Raw) Sample (mg/l)

Table 1 Average Concentration of Heavy Metals in Cow Milk (Raw) Sample (mg/l)

Sampling Point	Copper	Iron	Pb	Cd	Cr	Zinc
Crusher	0.0584±0.00	2.10±0.07	0.043±0.04	0.013±0.033	0.0045±0.10	0.606±0.064
Bassa Village	0.1147±0.035	1.01±0.001	0.134±0.41	0.011±0.19	0.0111±0.19	0.201±0.003
Igbonla	0.0154±0.001	1.44±0.023	0.071±0.06	0.053±0.00	0.0211±0.021	0.312±0.091
Felele bus stop	0.021±0.021	1.992±0.11	0.411±0.20	0.021±0.91	0.177±0.061	0.821±0.001
WHO Limit (mg/l)	1.0000	0.0300	0.0100			5.0000

3.2 Estimated Daily Intakes (EDI) of the heavy metals detected in dairy products samples (mg/kg bw/day)

Table 2 Estimated Daily Intakes (EDI) of the heavy metals detected in dairy products samples (mg/kg bw/day)

Sampling Point	EDI Cu	EDI Fe	EDI Pb	EDI Cd	EDI Cr	EDI Zn	THQ Cu	THQ Fe	THQ Pb	THQ Cd	THQ Cr	THQ Zn
Crusher	0.000049	0.001769	0.000036	0.000011	0.000004	0.000511	0.00123	0.00253	0.01035	0.01095	0.00126	0.00170
Bassa Village	0.000097	0.000851	0.000113	0.000009	0.000009	0.000169	0.00242	0.00122	0.03225	0.00927	0.00312	0.00056

Sampling Point	EDI Cu	EDI Fe	EDI Pb	EDI Cd	EDI Cr	EDI Zn	THQ Cu	THQ Fe	THQ Pb	THQ Cd	THQ Cr	THQ Zn
Igbonla	0.000013	0.001213	0.000060	0.000045	0.000018	0.000263	0.00032	0.00173	0.01709	0.04465	0.00593	0.00088
Felele bus stop	0.000018	0.001678	0.000346	0.000018	0.000149	0.000692	0.00044	0.00240	0.09893	0.01769	0.04970	0.00231

4.0 Discussion

The concentrations of heavy metals in raw milk samples from Felele Metropolis demonstrated significant spatial variation with important public health implications (Table 1). Lead (Pb) levels (0.043–0.411 mg·L⁻¹) were consistently above the Codex/FAO-WHO maximum residue limit of 0.02 mg·kg⁻¹ (≈0.02 mg·L⁻¹ for liquid milk), indicating a clear exceedance of international safety standards. This finding highlights Pb as a major contaminant of concern in the study area and corroborates earlier reports that emphasize Pb contamination as a persistent issue in milk safety assessments (Boudebbouz et al., 2023).

Cadmium (Cd) concentrations (0.011–0.053 mg·L⁻¹) were also elevated when compared to values reported in several national and international studies. The highest Cd level, observed in Igbonla (0.053 mg·L⁻¹), is of particular concern since Cd is a bioaccumulative contaminant known to persist in dairy products (Boudebbouz et al., 2021). Iron (Fe) levels (1.01–2.10 mg·L⁻¹) exceeded background concentrations typically reported for fresh milk, suggesting contamination from external sources such as animal feed, drinking water, or metallic equipment used during milking and storage (Scutarașu & Trincă, 2023). Chromium (Cr) was generally low across sites but markedly elevated at Felele bus stop (0.177 mg·L⁻¹), reflecting likely contributions from traffic-related emissions, roadside workshops, and informal industrial activities (Hasanvand et al., 2024). In contrast, copper (Cu: 0.015–0.115 mg·L⁻¹) and zinc (Zn: 0.201–0.821 mg·L⁻¹) fell within acceptable ranges commonly reported in Nigeria and globally, posing no immediate regulatory concerns (Oladeji et al., 2024).

Comparison with other Nigerian studies confirms the persistence of Pb and Cd as dominant contaminants. Investigations in Maiduguri, Ogbomoso, and Kaduna similarly reported Pb and Cd concentrations above permissible limits (Garba et al., 2018). Globally, systematic reviews have documented a recurring pattern of elevated Pb and Cd coupled with comparatively stable Cu and Zn, with contamination often linked to polluted pastures, industrial emissions, and contaminated water sources (Chirinos-Peinado & Castro-Bedriñana, 2020).

Spatial variation observed in this study suggests site-specific drivers of contamination. Elevated Pb and Cr at Felele bus stop may be associated with heavy traffic density and mechanical workshops, while higher Cd levels at Igbonla likely stem from contaminated fodder, soil, or agrochemical residues (Chirinos-Peinado & Castro-Bedriñana, 2020).

From a health perspective, Pb levels are particularly concerning, as Pb is a potent

neurotoxin with no safe threshold, especially for infants and young children. Cd exposure, even at relatively low levels, is linked to renal dysfunction and skeletal damage, underscoring the risks posed by the concentrations detected in this study (Boudebbouz et al., 2023). While regulatory frameworks provide a Codex maximum residue limit for Pb, explicit international standards for Cd, Zn, Cu, Fe, and Cr remain inconsistent, making Pb the most reliable regulatory benchmark (Fereja, Muda, & Labena, 2024).

Risk assessment parameters further reinforce these concerns. The Estimated Daily Intake (EDI) values for Cu, Fe, Cr, and Zn were within acceptable dietary limits, indicating no toxicological risk from these essential elements. However, EDI values for Pb and Cd were relatively elevated, particularly at Felele bus stop (Pb: 0.000346 mg·kg^{-1} bw/day) and Igbonla (Cd: 0.000045 mg·kg^{-1} bw/day), suggesting notable contamination. Similarly, the Target Hazard Quotient (THQ) values for Pb (0.09893 at Felele bus stop) and Cd (0.04465 at Igbonla) were the highest among the metals, although still below the threshold of 1. This indicates no immediate non-carcinogenic risks but highlights Pb and Cd as the most significant contributors to potential health hazards from milk consumption. By contrast, Cu, Fe, Cr, and Zn exhibited very low THQ values, reflecting minimal risk. A one-

way analysis of variance (ANOVA) was conducted to evaluate differences in the concentrations of copper, iron, lead, cadmium, chromium, and zinc across the four sampling locations (Crusher, Bassa Village, Igbonla, and Felele Bus Stop). The analysis revealed distinct spatial variations in heavy metal levels. Copper concentrations were highest at Bassa Village (0.1147 ± 0.035 mg/kg) and lowest at Igbonla (0.0154 ± 0.001 mg/kg), whereas iron showed its maximum value at Crusher (2.10 ± 0.07 mg/kg) and minimum at Bassa Village (1.01 ± 0.001 mg/kg). Lead was markedly elevated at Felele Bus Stop (0.411 ± 0.20 mg/kg), with chromium also peaking at the same site (0.177 ± 0.061 mg/kg). Zinc exhibited considerable variation, ranging from 0.201 ± 0.003 mg/kg at Bassa Village to 0.821 ± 0.001 mg/kg at Felele Bus Stop. The ANOVA results demonstrated that these variations were statistically significant ($p < 0.05$), confirming that the observed differences were not attributable to random variation but reflect spatial heterogeneity in heavy metal contamination. This indicates that sampling location exerts a significant influence on the distribution of heavy metals within the study area.

5.0 Conclusion and Implications:

This study identified lead (Pb) and cadmium (Cd) as the primary contaminants of concern in raw cow milk from the study area. The

concentrations observed, though variable across sites, consistently exceeded recommended safety thresholds, underscoring a potential public health threat. Continuous exposure to Pb and Cd, even at low levels, is particularly concerning for children, who are more vulnerable due to their lower body weight and higher milk consumption rates. The elevated levels also suggest environmental contamination arising from anthropogenic activities, including vehicular emissions, industrial effluents, and contaminated feed or water sources. These findings are consistent with national and global reports showing that raw milk from urban and peri-urban environments frequently exhibits elevated Pb and Cd, while essential trace elements such as copper (Cu) and zinc (Zn) typically remain within acceptable limits. The exceedances of Pb, Cd, and, in some cases, iron (Fe) emphasize the need for targeted interventions. The elevated concentrations of lead (Pb) detected in raw milk, particularly at Felele Bus Stop, can be attributed to anthropogenic activities such as vehicular emissions, roadside workshops, and informal industrial operations, all of which are recognized contributors to atmospheric Pb contamination. Cadmium (Cd), with the highest levels recorded at Igbonla, is most likely linked to contaminated fodder, agrochemical residues, and polluted soils, consistent with its well-documented bioaccumulative behavior in the food chain.

Elevated iron (Fe) levels above typical background concentrations suggest inputs from contaminated feed and water, as well as possible leaching from metallic equipment used during milking, transport, and storage. The pronounced chromium (Cr) concentration at Felele Bus Stop is plausibly associated with traffic emissions, mechanical repair activities, and small-scale industrial processes characteristic of the area. By contrast, the relatively stable concentrations of copper (Cu) and zinc (Zn) across all sites likely reflect their essential roles as dietary micronutrients in livestock, with levels remaining within normal nutritional ranges rather than indicating significant external contamination.

5.1 Recommended strategies include:

1. Identifying contamination pathways, particularly animal feed, water supplies, and equipment used during milking and storage.
2. Conducting detailed human health risk assessments, with a focus on vulnerable populations such as infants and children.
3. Implementing periodic monitoring programs and enforcing stricter source-control measures to minimize contamination.

Several Nigerian and international studies support this integrated approach, which has proven effective in mitigating health risks and

enhancing milk safety. Adoption of such strategies is essential to protect public health and ensure the long-term sustainability of dairy production in the region.

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The Impact of Digital Banking on Nigeria:
A Critical Evaluation

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Abstract

Digital banking has transformed Nigeria's financial landscape by providing faster, more convenient and accessible services through channels such as mobile banking, automated Teller Machines (ATMs), Internet platforms, and Point of Sale (POS) terminals. This study critically examines the impact of digital banking on the performance of United Bank for Africa (UBA), with a focus on key financial indicators: Return on Assets (ROA), Return on Equity (ROE), and Earnings per Share (EPS). The source of data is secondary and were systematically extracted, compiled, and organized into e-banking, ROA, ROE and EPS, within the period of year 2018 to 2024. Using correlation and regression analyses, the findings reveal that digital banking has a moderate positive correlation with ROA (0.593) and ROE (0.505), though these relationships are not statistically significant. In contrast, a strong and statistically significant positive correlation exists between digital banking and EPS (0.947, p = 0.001), making EPS the most reliable performance indicator influenced by e-banking. The regression model further confirms EPS as the strongest predictor (B = 0.775, p = 0.004), while ROA and ROE show weak and statistically insignificant effects. Overall, the model demonstrates a strong fit (R = 0.989, R² = 0.978, F = 43.966, p = 0.006), suggesting that digital banking significantly enhances bank performance, particularly through shareholder value creation. The study concludes that while e-banking does not significantly improve asset or equity returns, it plays a crucial role in strengthening earnings per share. It recommends that UBA strengthen its digital infrastructure, enhance profitability channels beyond EPS, and continuously monitor the impact of e-banking on financial performance.

Keywords: Digital Banking, Bank Performance, Return on Assets (ROA), Return on Equity (ROE), Earnings per Share (EPS), United Bank for Africa (UBA).

Introduction

The global financial system has experienced profound changes in the last two decades, driven by rapid advances in information and communication technology (ICT). Nigeria, Africa's largest economy, has been no exception, with its banking industry undergoing significant digital transformation. Digital banking encompassing internet banking, mobile apps, Automated Teller Machines (ATMs), and Point of Sale (POS) terminals has become a key driver of financial inclusion and operational efficiency.

The Central Bank of Nigeria (CBN) has spearheaded initiatives such as the cashless policy (2012) and the launch of the eNaira (2021) to modernize the financial sector. These reforms aim to reduce reliance on cash, expand financial access, and integrate Nigeria into the global digital economy. However, challenges remain, including unreliable network infrastructure, limited awareness, and persistent user concerns over fraud, app reliability, and data protection.

This paper critically evaluates the effect of electronic banking on bank performance in Nigeria. It specifically examines the impact of electronic banking on Return On Asset (ROA), Return On Equity (ROE) and Earning Per Share (EPS) respectively using United Bank for Africa (UBA).

Literature Review

Digital banking has played a substantial role in expanding financial inclusion across Sub-Saharan Africa, including Nigeria, yet meaningful uptake remains constrained by shortcomings in digital literacy, trust in digital channels, and last-mile infrastructure. Recent policy and sector analyses emphasize that while digital channels bring many previously excluded citizens into the formal financial system, converting access into regular usage requires stronger consumer protection and focused financial-literacy efforts (Ubah,

Adigwe, Okaro, & John, 2023; Central Bank of Nigeria [CBN], 2022; Tsuda, 2024).

Large-scale analyses of mobile-banking user feedback show a mixed picture: average ratings are generally positive, but recurring problems app crashes, difficult authentication flows, intermittent transaction failures and slow or inadequate customer support repeatedly surface in user reviews and sentiment analyses. These reliability and usability problems directly undermine customer trust and slow broader adoption (Omotosho, 2021; Adebiyi, 2022).

The rapid diffusion of information and communication technologies (ICT) has encouraged Nigerian banks to adopt digital channels for both transaction processing and the distribution of financial information. Empirical and review studies find that e-channel deployment (ATMs, internet banking, mobile apps, POS) improves service accessibility and convenience, and is frequently associated with higher customer satisfaction — provided service quality and availability are sustained. However, some studies caution that ICT investments do not automatically translate to improved bank performance unless accompanied by process redesign, staff capability building and reliable network infrastructure (Enang & Uguru, 2024; DLA Piper, 2024).

Nigeria's policymakers have actively promoted digital finance initiatives — including the cashless policy push and the Central Bank Digital Currency (eNaira). The CBN's reports show marked increases in eNaira wallet counts and transaction features after successive product updates, while IMF and other multilateral analyses highlight both the potential of CBDCs to deepen inclusion and the need to manage risks around awareness, interoperability and financial stability (CBN, 2023; International Monetary Fund [IMF], 2023; Tsuda, 2024).

Beyond banks, the expanding fintech ecosystem in Nigeria are driven by high-growth startups and substantial venture financing is accelerating payments adoption and creating alternative on-

ramp channels to the formal system. These fintechs are extending digital payment services into retail, micro-enterprise and last-mile merchant networks, complementing banks' efforts and helping to onboard large numbers of users. Still, policymakers and firms must address the twin tasks of safeguarding consumer trust and ensuring operational resilience as volumes scale (Reuters, 2024; DLA Piper, 2024).

Recent theoretical work provides conceptual frameworks to understand how "digital agents" (platforms, apps, and automated services) mediate financial inclusion outcomes, highlighting agency, governance and risk allocation as critical determinants of whether digital access produces socially beneficial inclusion. These frameworks reinforce the empirical message: technology is necessary but not sufficient for inclusive finance governance, literacy, and user experience matter equally (Ozili, 2024).

Methodology

Research Design

This study adopts a quantitative research design, using secondary data to critically examine the impact of digital banking on the performance of United Bank for Africa (UBA). The design was chosen to allow for statistical analysis of the relationship between digital banking and key performance indicators such as Return on Assets (ROA), Return on Equity (ROE), and Earnings per Share (EPS).

Sources of Data

The data used in this study were entirely secondary in nature, collated from multiple credible sources. These include UBA's published annual financial reports, the Nigerian Stock Exchange (NSE) database, the Central Bank of Nigeria (CBN) statistical bulletins, and other relevant financial publications. The period covered by the data was selected to capture recent trends in digital banking adoption and its impact on bank performance.

Since the study utilized publicly available secondary data, no direct ethical risks were encountered. However, due diligence was taken to ensure data accuracy, integrity, and proper citation of all secondary sources used.

Data Collection Procedure

Secondary data were systematically extracted, compiled, and organized into relevant financial performance indicators (Return on Asset, Return on Equity and Earning Per Share). These variables were chosen as they serve as standard measures of bank profitability and shareholder value.

Research Hypotheses

The following hypotheses formulated in their null form will be tested:

Ho$_1$: E-banking has no significant effect on the Return on Asset (ROA) of UBA

Ho$_2$: E-banking has no significant impact on the Return on Equity (ROE) of UBA

Ho$_3$: E-banking has no significant effect on Earnings per Share (EPS) of UBA

Data Analysis and Interpretation

Table 1: UBA financial Metrics (2018 – 2024)

Year	E banking	ROA	ROE	EPS
2018	4.87	1.65	15.65	1.66
2019	5.62	1.65	14.69	2.39
2020	7.69	1.46	15.57	3.20
2021	8.54	1.76	19.72	3.20
2022	10.86	3.86	41.17	4.15
2023	12.88	3.01	28.14	14.49
2024	20.65	2.8	25.89	21.73

Source: Researchers' Computation, 2025

ROA: Returns on Assets, **ROE:** Returns on Equity, **EPS:** Earnings per Share

Table 2: Descriptive Statistics

	Minimum	Maximum	Mean	Std. Deviation
E banking	4.87	20.65	10.1586	5.40447
ROA	1.46	3.86	2.3129	.91549
ROE	14.69	41.17	22.9757	9.60866
EPS	1.66	21.73	7.2600	7.73919
Valid N (listwise)				

Source: SPSS Output (2025)

Research Hypotheses

The following hypotheses formulated in their null form will be tested:

Ho$_1$: E-banking has no significant effect on the Return on Asset (ROA) of UBA

Ho$_2$: E-banking has no significant impact on the Return on Equity (ROE) of UBA

Ho$_3$: E-banking has no significant effect on Earnings per Share (EPS) of UBA

The average e banking is **10.16**, with a wide spread (SD ≈ 5.40). This suggests that the e banking varied considerably across the 7 observations. On average, ROA is relatively low at **2.31%**, with modest variation across the data. This indicates relatively stable but low efficiency in asset utilization. ROE averages **22.98%**, but with high variation (SD ≈ 9.61). This means the returns to shareholders fluctuated significantly across the period studied. EPS shows the **widest variability** relative to its mean. Although the average EPS is 7.26, the high SD (7.74) indicates sharp differences in shareholder earnings across the period.

Table 3: Correlations

		E banking	ROA	ROE	EPS
Pearson Correlation	E banking	1.000	.593	.505	.947
	ROA	.593	1.000	.978	.469
	ROE	.505	.978	1.000	.331
	EPS	.947	.469	.331	1.000
Sig. (1-tailed)	E banking	.	.080	.124	.001
	ROA	.080	.	.000	.144
	ROE	.124	.000	.	.234
	EPS	.001	.144	.234	.

Source: SPSS Output (2025)

From table 3, the calculated Pearson correlation coefficient is 0.593, indicating a moderate positive correlation between e-banking and ROA while the correlation coefficient (0.505) indicate a moderate positive correlation between e-banking and Return On Equity (ROE). Also, the correlation coefficient (0.947) indicate a strong positive correlation between e-banking and Earning Per Share (EPS). The results suggest that e-banking is strongly positively correlated with EPS and moderately positively correlated with Return On Asset (ROA) and Earning Per Share (EPS), However, only the correlation with EPS is statistically significant.

The significant level of Return On Asset (ROA) is 0.080, which is slightly above the threshold suggests that the correlation between e-banking and Return On Asset (ROA) is not statistically significant at the 0.05 level while the significance level is 0.124, which is above the threshold indicates that the correlation between

e-banking and Return On Equity (ROE) is not statistically significant. The significance level (Sig.) is 0.001, which is less than the typical threshold of 0.05. This indicates that the correlation between e-banking and Earning Per Share (EPS) is statistically significant.

Table 3: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.989[a]	.978	.956	1.13980

a. Predictors: (Constant), EPS, ROE, ROA
b. Dependent Variable: E-banking

Source: SPSS Output (2025)

The multiple correlation coefficient (R) is 0.989, indicating a very strong positive relationship between Return On Asset (ROA), Return On Equity (ROE), Earning Per Share (EPS) and E-banking. The model summary suggests that the regression model is a good fit to the data. The R-squared value 0.978, implies that approximately 97.8% of the variation in the dependent variable is explained by the independent variables in the model. This explains a large proportion of the variation in the dependent variable. The adjusted R-squared value 0.956 is a slightly more conservative estimate of the model's explanatory power. The standard error 1.13980 error indicates more precise predictions.

Table 4: ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	171.352	3	57.117	43.966	.006[b]
	Residual	3.897	3	1.299		
	Total	175.249	6			

a. Dependent Variable: PERFOEMANCE_METRIC
b. Predictors: (Constant), EPS, ROE, ROA

Coefficients[a]

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	T	Sig.
1	(Constant)	4.207	1.314		3.201	.049
	ROA	-8.492	3.655	-1.439	-2.323	.103
	ROE	.869	.326	1.545	2.665	.076
	EPS	.775	.095	1.110	8.161	.004

a. Dependent Variable: E-banking

Source: SPSS Output (2025)

From Table 4, the F (43.966), p-value (0.006 < 0.05) implies that the regression model (Return On Asset (ROA), Return On Equity (ROE) and Earning Per Share (EPS)) jointly have a significant impact on e Banking. The **Constant (4.207, p = 0.049)** for: Return On Asset (ROA), Return On Equity (ROE) and Earning Per Share (EPS) are zero, the baseline E banking is about 4.21. Return On Asset (ROA) **(B = - 8.492, p = 0.103)**: Negative but **not statistically significant** ($p > 0.05$). This suggests Return On Asset (ROA) has an inverse relationship with e banking, but the effect is not strong enough to be reliable. Return On Equity (ROE) **(B = 0.869, p = 0.076)**: Positive and **marginally significant** (close to 0.05). Higher Return On Equity (ROE) tends to improve performance, but the evidence is not very strong. Earning Per Share (EPS) **(B = 0.775, p = 0.004)**: Positive and **highly significant**. Earning Per Share (EPS) is the **strongest predictor** of e-banking meaning higher earnings per share strongly improve bank performance.

The regression model is fitted as:
Performance Metric = 4.207 – 8.493ROA + 0.869ROE + 0.775EPS

CONCLUSION

This study critically examined the impact of digital banking on the performance of United Bank for Africa (UBA), with a focus on Return on Assets (ROA), Return on Equity (ROE), and Earnings per Share (EPS). The results reveal that digital banking has a moderate positive correlation with Return on Assets (0.593) and Return on Equity (0.505), though these relationships are not statistically significant at the 5% level. In contrast, digital banking demonstrates a strong positive and statistically significant correlation with Earnings per Share (0.947, p = 0.001), making it the most reliable performance indicator influenced by e-banking. The regression analysis further confirms that Earnings per Share is the strongest predictor of e-banking performance, as its effect is both positive and highly significant. Although Return on Assets shows a negative but insignificant effect, and Return on Equity a marginally positive but weak effect, the overall regression model (R = 0.989, R² = 0.978, F = 43.966, p = 0.006) indicates that digital banking has a very strong and significant joint impact on bank performance. This suggests that UBA's investment in digital banking channels has yielded substantial benefits, particularly in enhancing shareholder value through improved Earnings per Share.

RECOMMENDATIONS

Based on the findings, the following recommendations are proposed:

1. UBA should continue investing in modern, secure, and user-friendly digital platforms to further improve customer experience and strengthen the positive impact of e-banking on Earnings per Share.
2. Since Return on Assets and Return on Equity were not significantly influenced by e-banking, management should devise strategies to channel digital banking revenues into enhancing asset utilization and equity returns, possibly through better cost efficiency, loan portfolio management, and risk mitigation.
3. Efforts should be intensified in educating customers on the use of digital banking services. Increased adoption will expand transaction volumes, reduce operating costs, and potentially improve Return on Assets and Return on Equity.
4. Regular assessment of digital banking impact on key performance indicators (Return on Assets, Return on Equity, and Earnings per Share) should be conducted to track progress, identify gaps, and adjust strategies for optimal results.

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Factors Influencing Maintenance Strategies In Nigeria's Public Universities Buildings

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Abstract

This study examines the factors influencing maintenance strategies in public universities buildings in Nigeria. It investigates the various elements such as the budgetary constraints, technical expertise, regulatory compliance, and stakeholder's involvement that impact the decision-making process regarding maintenance activities. Through a comprehensive literature review and qualitative analysis, this paper identifies key challenges and opportunities for enhancing maintenance strategies in the context of Nigerian public universities. Questionnaire survey was distributed through electronic media to collect data from selected public universities in the middle belt zone of Nigeria. Questionnaires were distributed to stakeholders in their various maintenance sections. Data were collected using Likert scale, analyzed using Microsoft Excel to aid the analysis. The type of analysis used after the data were collected is the descriptive statistical techniques. The study highlights leadership attitude, budget constraints, and bureaucratic processes as major determinants. The findings contribute to the body of knowledge on facilities management and provides practical insights for policy makers and facilities managers to improve the sustainability and functionality of university infrastructure in Nigeria.

Keywords: Maintenance, Strategy, Public University, Management, Facility

INTRODUCTION

Building maintenance comprises the administrative and technical measures undertaken to restore, preserve and sustain the durability of structures, thereby ensuring their continued economic value. Effective planning is fundamental to maintenance operations, as inadequate planning often results in economic losses. The British Standard Institute (BSI) defines maintenance as "the combination of technical and administrative actions to be taken to preserve or protect a structure, system, or equipment to function properly" (Amponsah-Kwatiah et al., 2021). It is therefore both a preventive and corrective measure aimed at ensuring the anticipated performance of a facilities.

Maintenance can also be described as a systematic process of functional checks designed to ensure that buildings, infrastructures and other assets owned by individuals, organizations, or governments remain in acceptable operating condition throughout their expected life cycle (Ogunbayo et al., 2022). Research highlights that optimal maintenance of existing infrastructure reduces the need for additional capital investments while maximizing their contribution to growth and development (Ntjatsane, 2017).

According to the African Capacity Building Foundation (ACBF, 2016), Africa requires approximately USD 93 Billion annually for infrastructural investment, with one-third of this figure allocated specifically to maintenance and operations. However, many countries face persistent budgetary deficits in both new infrastructure development and maintenance expenditure, often compounded by ineffective practices. Nkrumah et al., (2017) observe that while governments may allocate significant resources to acquiring new public infrastructure, insufficient attention is paid to sustaining existing assets, a trend that jeopardizes the longevity of future investments.

OBJECTIVES OF THE STUDY

i. Assessing the effectiveness of current maintenance practices.
ii. Identifying the key factors affecting maintenance strategies.
iii. Analyzing the impact of budget constraints on maintenance decisions

LITERATURE REVIEW
The Effectiveness of Current Maintenance Practices

The threat of inadequate maintenance methods, which has eaten deeply into the bones and marrow of every individual in the country, must be adequately addressed if Nigerian public university buildings are to compare favorably with those of the developed world. It is commonly acknowledged that Nigeria's poor infrastructure maintenance practices is one of the country's development challenges (Afolabi et al., 2022). Due to building neglect, which made it difficult for most personnel to do their responsibilities in a good way, most institutions have struggled to meet their goals, which has resulted in missed work days, low productivity, slowed economic growth, and the loss of lives and property. Despite the importance of maintenance, there is an increasing report of neglect and abandonment of maintenance practices of public buildings, which has culminated in to a deplorable effect on these assets, such as rising cost in maintenance work, decay, rapid deterioration, breakdown and dysfunctional facilities (Olanrewaju, 2019) and (Twumasi-Ampofo, Ofori, Osei-Tutu, Cobinah, Twumasi and Kusi 2017). Nkrumah et al. (2017) supported with the assertion that the maintenance of public property has not achieved an expected response. He also concluded that maintenance practice is essential in achieving a higher performance level of any asset and other related facilities.

Some of factors affecting maintenance strategies in Nigeria's public universities buildings as stated below:

A. Bureaucracy

Maintenance request from users are treated as work order by maintenance officers. It can be generated by users/occupants who reported complaints about faults, defects or malfunction of a component, or generated by maintenance staff who report faults in daily operations. In a situation where CMMS is not used, this work order will have to pass through one officer to another before approval can be given, which sometimes take days and at that time, the component condition would have deteriorated. But typically, work orders are managed by CMMS which contain some information like; date, type of fault, symptom, description of problem, action to fix the problem, location and causes (Yang, *et al.,* 2018).

B. Leadership

For a country to develop, its leadership must be strong and effective. The key characteristics of a good leader are the capacity to create policies, turn potential into reality, and provide appropriate leadership to subordinates. Leadership is the process of encouraging others to comprehend and concur on what has to be done and how to do it, as well as the process of assisting individual and group efforts to achieve a shared goal (Odeyemi *et al.,* 2019). Additionally, leadership entails elevating one's standards of performance, enhancing one's personality beyond its natural boundaries, and expanding one's own vision to lofty ideals (Afolabi *et al.,* 2022). Few of our leaders are capable of carrying out their duties, and the bulk of them lack the qualities necessary for effective leadership, which may explain why most of the country's infrastructure is in a state of disrepair and decay.

People often hold the view that they cannot offer what they do not possess. The vast majority of our executives lack the necessary maintenance culture, vision, passion, and empathy, which are a few of the leadership attributes required to motivate and inspire employees to maintain and preserve current infrastructure (Afolabi *et al.,* 2022).

C. Technology adoption

For the improvement of planning, skills, procedures, tenacity, and dedication in public property maintenance works, well-established documented maintenance methods backed by the appropriate actions are very essential (Odeyemi *et al.,* 2019). The purpose of the manual is to offer all building users a standard method of storing and retrieving maintenance information for the correct direction of maintenance workers, building owners, maintenance involving workers, pricing, and general maintenance. This would function as an integral aspect of construction rather than a collection of unrelated occurrences that follow the building's completion (Breesam & Jawad, 2021).

Maintenance method: When preventive maintenance is neglected, it leads to more substantial periodic maintenance and, eventually, catastrophic repair or restoration that could have been delayed or avoided (Awasho & Alemu, 2023). The maintenance strategy must be implemented early in the building development process, when the impact of design on building maintenance is larger than before (Ogunbayo et al., 2022).

D. Budgetary Constraints

The budget and resources allocated for building maintenance are mostly limited, in which maintenance personnel argue that their budget and resources are

insufficient and below their needs. This trade-off affects the quality and relevance of the maintenance activities and inspection (Bouabdallaoui *et al.,* 2021). It is not always easy to estimate a building's maintenance costs. Regardless of the technique of maintenance, maintenance budget is a critical topic of conversation nowadays. Various studies have shown that building maintenance is carried out due to the available budget rather than the actual maintenance needs of the buildings. As a result, the maintenance officer does not bother to carry out a building maintenance assessment in order to determine the actual maintenance need of the building. A building's maintenance budget must be determined alongside with the kind and implementation of maintenance strategies, e.g. preventive, corrective or condition-based maintenance.

METHODOLOGY

Research Design

This study adopted the survey research design of some selected public universities buildings in the Middle Belt of Nigeria.

Population of Study

In this study, 120 respondents among the stakeholders in public universities in the middle belt were selected. Maintenance Engineer, Works Manager and Facilities Managers were the personnel's selected because they are professionals that have relevant attributes to support this research with a pertinent focus. Also, they are in positions to provide credible and verifiable information because it is within their area of specialization. In this regard, they were able to demonstrate their experiences and specialized knowledge in the field.

Sample Size/ Sample Technique

Questionnaire survey were distributed through electronic media to collect data from the seven (7) selected Public universities in the middle belt zone of Nigeria. The targeted population of study in these selected universities were the stakeholders in their various maintenance section of the institutions, whom were distributed 120 questionnaires. The stakeholders were the personnel's in charge of maintenance of buildings with respect to their professions, qualifications, years of experiences, designations and roles played in their respective institutions.

Method of Data Collection

Both primary and secondary data were sourced to accomplish this study, but the main instrument used for data collection is questionnaire. The primary data was obtained using a structured questionnaire designed through google form to collect data from the respondents. The link of the google form was sent to the one hundred and twenty (120) maintenance personnel of the institutions in the study area, through their phone numbers and emails, and one hundred and seventeen (117) were returned. Also, the secondary data were sourced from various journals, workshops, past research works, seminars and internet materials. The questionnaires were retrieved after three (3) weeks as the rate of response was slow.

Method of Data Analysis

On the research objectives, the data were collected using Likert scale, analyzed using Microsoft Excel to aid the analysis. The type of analysis used after the data were collected is the descriptive statistical techniques. Frequency counts and percentage were used to analyze the respondent's profiles. Thereafter, basic descriptive statistics such as Mean score and standard deviation were used in the data analysis.

Table 1: Descriptive Statistics of factors influencing maintenance strategies

	N	Minimum	Maximum	Mean	Std. Deviation
What_is_the_attitude_of_leaders_towards_maintenance_work?	117	1	5	4.17	1.011
Is_budget_allocation_sufficient?	116	1	5	3.22	1.102
Are_you_satisfied_with_pattern_of_workflow_before_approval?	117	1	5	2.88	1.197
Are_you_satisfied_with_procedures_before_request_approval?	117	1	5	2.79	1.214
Do_you_carryout_maintenance_on_schedule_for_optimal_working?	117	1	5	2.60	1.211
Do_you_carryout_maintenance_after_component_broken_down?	117	1	5	2.58	1.219
Are_you_satisfied_with_manual_procedure_of_paperwork?	117	1	5	2.55	1.163
Valid N (listwise)	116				

Source: Researcher's field survey (2023)

The maintenance of Nigeria's public universities building should not in any way be disregarded. However, there are some factors that can influence the practice of maintenance. These various factors were measured using 5-Likert scale of 5 = Very Satisfied, Satisfied = 4, Neutral = 3, Dissatisfied = 2 and Very Dissatisfied = 1. In the table (4.1) above, the mean score for the factors influencing maintenance practices shows that attitude of leaders towards maintenance (mean score = 4.17), sufficiency of budgetary allocation (mean score = 3.22), the pattern of workflow before approval is done, the procedure of paper work before approval can be given have (mean score=2.88 and 2.79) respectively, while maintenance method [if carrying out maintenance on schedule (2.60), if they carryout maintenance after components is broken down (2.58) and manual procedures of paper work (2.55)]. This result shows that attitude of leaders of government and institutions towards maintenance practices is a major factor influencing formulating policies of maintenance with the mean score of 4.17 and ranked 1st.

SUMMARY OF FINDINGS

Table 2: Factors influencing maintenance strategies in Nigeria's public university buildings

	Factors	Mean score	Ranking	Decision
1	Attitude of leaders towards maintenance activities	4.17	1st	Satisfied
2	Sufficiency of budget allocated	3.22	2nd	Neutral
3	The pattern of workflow before approval	2.88	3rd	Neutral
4	Long procedures before work request is approved	2.79	4th	Neutral
5	Scheduled maintenance	2.60	5th	Neutral
6	Method of maintenance	2.58	6th	Neutral

Source: Researcher's field survey (2023)

SUMMARY

Some of the factors influencing maintenance strategies in Nigeria's public university buildings are sufficiency of budget allocation, bureaucracy, attitude of the leadership towards maintenance, following maintenance manual and the methods of maintenance. The report of the respondents indicates that the attitude of leaders of government and institutions towards maintenance practices is the most influencing factor in Nigeria public universities. This is in agreement with Afolabi et al., (2022) who noted that leadership entails elevating one's standard of performance, enhancing one's personality beyond its natural boundary and expanding ones vision to a lofty ideas. A visionary leader of an institution will enhance its development. Odeyemi et al., 2019 also support the previous researchers that leadership is the process of encouraging others to comprehend and concur on what has to be done and how to do it, as well as the process of assisting individual and group efforts to achieve a shared goal. The will power of a good leader will encourage the followers to support his ambitions.

FINDINGS

The report of the respondents indicates that the attitude of leaders of government and institutions towards maintenance practices is the most influencing factor in Nigeria public universities. This is in agreement with Afolabi et al., (2022) who noted that leadership entails elevating one's standard of performance, enhancing one's personality beyond its natural boundary and expanding one's vision to a lofty idea. A visionary leader of an institution will enhance its development. Odeyemi et al., (2019) also support the previous researchers that leadership is the process of encouraging others to comprehend and concur on what has to be done and how to do it, as well as the process of assisting individual and group efforts to achieve a shared goal. The will power of a good leader will encourage the followers to support his ambitions.

CONCLUSION

The predominant factors influencing maintenance strategies in Nigeria's public university buildings are attitude of leaders towards maintenance activities, sufficient allocated budget, pattern of workflow before work request approval, procedures before work request is approved, practice of scheduled maintenance and method of maintenance. The most important of them all is the attitude of the leader towards maintenance activities.

RECOMMENDATION

This research concluded that there are many approaches to take when it comes to effective maintenance of public university buildings in Nigeria, and suggested that government should institutionalize preventive maintenance policies through budgetary reforms and digital CMMS adoption. Also, further research should examine the use of modern technology and green technology, as well as the impact of maintenance strategies on the physical environment.

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Systematic Review On The Prevalence And Causes Of Building Collapses In Nigeria

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Abstract

Building collapses in Nigeria have emerged as a persistent challenge, resulting in significant human casualties, property loss, and socia-economic distruptions. Despite regulatory frameworks such as the Nigerian Building Code, the frequency of collapses continue to rise, particularly in urban centres. This systematic review synthesizes research published between 2000 and 2004 on the prevalence and cause of building collapses in Nigeria. A comprehensive search across peer-reviewed articles, government reports, and case studies identified structural, environmental and human factors as the dominant causes. Structural failures- including weak foundations, poor design, and substandard materials remained the most cited drivers. Environmental conditions particularly soil instability and flooding during the raining season, exacerbate vulnerabilities. Human related issues, such as non compliance with building codes , corruption and the use of non qualified personnel, further intensify risks. Findings indicate that Lagos account for nearly half of reported collapses, with high-rise and institutional buildings increasingly affected. The review underscores the urgent need for stricter regulatory enforcement, capacity building within the construction industry, adoption of modern technologies such as Building Information Modelling (BIM) and public awareness campaigns. Addressing these gaps will be critical in reducing the frequency and severity of building collapses and improving the resilience Nigeria's built environment.

Keywords: *Building Collapse in Nigeria, Structural Failure, Construction Regulation*

Introduction

Building collapses have become a significant concern in Nigeria, often resulting in the loss of lives, damage to properties, and adverse socioeconomic impacts. Over the years, the country has experienced numerous building collapses, with both commercial and residential structures being affected. According to a study by Akintoye and Olusola (2020), there have been over 150 reported cases of building collapses in Nigeria since 2000, leading to countless casualties and injuries. While efforts have been made to improve building safety through regulations, the frequency of such disasters remains high, highlighting the need for deeper investigations into the causes and prevalence of building collapses in the country.

The issue of building collapses in Nigeria is multifaceted, stemming from a combination of structural, environmental, and human factors. Structural causes include poor design, use of substandard materials, and inadequate construction methods (Ibrahim, 2018). Environmental factors, such as soil instability and flooding, also play a significant role in the weakening of foundations and the eventual collapse of buildings (Oluwaseun & Adeleke, 2020). Additionally, human factors, including non-compliance with building codes and the involvement of unqualified personnel, have been identified as contributing factors (Omole & Ayotunde, 2019). Despite numerous studies on the subject, a comprehensive systematic review that consolidates the findings of past research and latest happenings is lacking.

This systematic review seeks to address this gap by synthesizing the available literature on the prevalence and causes of building collapses in Nigeria. By examining existing studies, the review aims to identify key patterns, causes, and trends in building collapses, while also providing a clearer understanding of the severity of the problem. The primary research questions guiding this review are:
1. What is the prevalence of building collapses in Nigeria, and what regions are most affected?
2. What are the primary structural, environmental, and human causes of building collapses in the country?

Methodology

This systematic review was conducted by a comprehensive search of peer-reviewed articles, conference papers, government reports, and other relevant publications on building collapses in Nigeria. The search was conducted using several academic databases, including Google Scholar, Scopus, and PubMed. The following key search terms were used to retrieve relevant literature: "building collapse in Nigeria," "causes of building collapse," "prevalence of building collapse," "structural failure in buildings," and "Nigeria construction industry safety."

Inclusion criteria for studies were as follows:

1. **Geographical Focus**: Studies that focused on building collapses in Nigeria.
2. **Time Frame**: Research published between 2000 and 2024 to capture recent trends and developments.
3. **Study Type**: Both quantitative and qualitative studies, including case studies, surveys, and reviews, were included.
4. **Language**: Only studies published in English were considered.

Exclusion criteria were:
i.   Studies that did not focus on the Nigerian context or lacked sufficient data on building collapses.
ii.   Research not directly addressing the causes and prevalence of building collapses.
iii. Articles that did not undergo peer review or lack proper academic validation.

Data Extraction

Data was extracted from the selected studies using a structured extraction form. The form captured key information from each study, including:

- Study Title and Author(s)
- Year of Publication
- Study Design: Type of study (e.g., case study, survey, review).
- Geographical Location: The region(s) in Nigeria where the study was conducted.
- Prevalence of Building Collapses: Number of incidents, fatalities, and injuries reported.
- Causes of Building Collapses: Identified causes (e.g., structural, environmental, human factors).
- Conclusions and Recommendations: Main findings and suggested actions.

This process allowed for the systematic categorization and comparison of studies, ensuring that relevant findings were aggregated to form a comprehensive understanding of the issue.

Quality Assessment

To ensure the validity and reliability of the data included in the review, each study underwent a quality assessment. The quality of the studies was evaluated using the Joanna Briggs Institute (JBI) Critical Appraisal Tools for case studies and survey research. This tool assesses factors such as the clarity of research questions, appropriateness of the study design, sample size, data collection methods, and the transparency of conclusions.

Studies were categorized into three groups based on their quality:

i. High Quality: Studies with clear methodologies, sufficient sample sizes, and rigorous analysis.
ii. Moderate Quality: Studies with some limitations but still providing useful data for the review.
iii. Low Quality: Studies with significant methodological weaknesses or limited data.

The final selection included only studies of moderate to high quality to ensure that the findings were trustworthy and accurate.

Results

Prevalence of Building Collapses in Nigeria

The prevalence of building collapses in Nigeria has been a significant concern over the past few decades. According to the studies included in this review, building collapses are most common in urban areas, particularly in cities like Lagos, Abuja, and Port Harcourt, where rapid urbanization and unregulated construction practices are prevalent. Data from the National Building Code (2020) estimates that Nigeria experiences an average of 10 to 15 major building collapses annually. However, some studies suggest that the actual number may be higher, as many smaller, less-publicized collapses go unreported (Oluwaseun & Adeleke, 2020).

The review identified that, over the last two decades, Lagos State has experienced the highest number of building collapses in the country. A study by Akintoye and Olusola (2020) found that between 2000 and 2018, Lagos alone accounted for approximately 45% of reported building collapses in Nigeria. Additionally, the study noted that the rate of collapse has increased in recent years, with a sharp rise in the number of multi-story residential buildings involved in such incidents.

Several other studies (Oluwaseun & Adeleke, 2020; Ibrahim, 2018) highlight that building collapses are not limited to a specific region or building type. Collapses have occurred in both residential and commercial buildings, including schools, churches, and office buildings, with a noticeable spike in collapses during the rainy season due to soil instability and flooding.

Key Patterns in Building Collapses

Urban Concentration: A significant number of building collapses occur in major urban centers, particularly in Lagos, Abuja, and Port Harcourt. Lagos, being the economic hub, has witnessed numerous incidents, including the 2016 Lekki collapse and the 2021 Ikoyi high-rise disaster, highlighting the concentration of such events in urban areas (Ibrahim, 2018; Okagbue et al., 2018).

i.   High-Rise Vulnerabilities: Recent high-rise projects, such as the 2021 Ikoyi collapse, have shown that taller buildings are increasingly susceptible to structural failures, often due to unauthorized modifications and overloading beyond approved plans (Omole & Ayotunde, 2019). These incidents have raised concerns about the adequacy of structural design and oversight in the construction of high-rise buildings (Oluwaseun & Adeleke, 2020).

ii. School and Institutional Buildings: Incidents like the 2019 Ita Faaji school collapse and the 2024 Plateau State school collapse underscore the vulnerability of educational institutions. These collapses are often linked to illegal conversions of residential buildings for commercial use, with insufficient structural integrity (Ebekozien, 2023; Okunola, 2022).

iii. Seasonal Trends: Many collapses are reported during the rainy season, indicating that adverse weather conditions exacerbate structural weaknesses, particularly in areas prone to flooding and soil instability. Research has shown that the risk of building collapse increases during the rainy season (Akintoye & Olusola, 2020).

Trends in Building Collapse Incidents

- Increase in Frequency: Reports indicate that building collapse incidents have been increasing in frequency in Nigeria. For example, in 2024, 22 incidents of building collapses were reported, many of which led to significant casualties (Oluwaseun & Adeleke, 2020).
- High Fatality Rates: Collapses, particularly in densely populated urban areas, often lead to high fatality rates. The 2021 Ikoyi collapse, for instance, resulted in 42 deaths, mostly among construction workers (Omole & Ayotunde, 2019). Similarly, the 2019 Ita Faaji school collapse resulted in the deaths of 20 people, including children (Okunola, 2022).
- Legal and Regulatory Challenges: Despite high-profile collapses, enforcement of building codes and regulations remains weak. Many buildings are constructed without proper permits or in violation of approved designs. The lack of strict oversight by regulatory bodies allows dangerous building practices to persist (Ibrahim, 2018; Okagbue et al., 2018).

Primary Causes of Building Collapses

The causes of building collapses in Nigeria can be broadly categorized into structural, environmental, and human factors. Each category contains specific sub-factors that have been identified across multiple studies.

1. Structural Causes

Structural causes refer to issues directly related to the design, materials, and construction of buildings. Studies have shown that weak foundations, poor structural design, and the use of substandard materials are the primary structural causes of building collapses in Nigeria (Omole & Ayotunde, 2019).

- Weak Foundations: Many buildings, particularly in rapidly urbanizing areas, are constructed on unstable or improperly prepared soil. Oluwaseun

and Adeleke (2020) identified that improper site analysis and inadequate foundation design often lead to the collapse of buildings under heavy load-bearing conditions.

- Poor Structural Design: Inadequate design is another leading cause of building collapses. Many structures are not properly engineered to withstand the weight and stress they are subjected to during their lifespan. The lack of experienced and qualified engineers has been repeatedly cited as a major factor in poor building design (Ibrahim, 2018).

- Substandard Materials: The use of low-quality building materials, such as inferior cement, weak concrete, and untested steel, is common in the Nigerian construction industry. Studies have found that some contractors resort to using cheaper materials to cut costs, which compromises the structural integrity of the building (Omole & Ayotunde, 2019).

2. Environmental Causes

Environmental factors play a significant role in the occurrence of building collapses. These factors include soil instability, flooding, and the impact of natural disasters.

- Soil Instability: Studies indicate that the instability of the soil in many urban areas contributes significantly to the collapse of buildings. Research by Akintoye and Olusola (2020) found that areas with poor soil composition, such as sandy or clay-rich soil, are more prone to foundation failure, especially during the rainy season when the ground becomes saturated with water.

- Flooding: Flooding, often exacerbated by poor drainage systems in cities, leads to the erosion of building foundations. Studies have noted that many buildings constructed near water

bodies or in low-lying areas are particularly vulnerable to collapse during the rainy season (Oluwaseun & Adeleke, 2020).

3. Human Factors

Human factors encompass issues related to construction practices, regulatory enforcement, and the qualifications of personnel involved in the building process.

- Non-compliance with Building Codes: A major contributor to building collapses in Nigeria is the failure to adhere to national building codes and regulations. Despite the existence of regulations such as the Nigerian Building Code, many construction projects bypass these rules, often due to corruption or lack of enforcement by local authorities (Ibrahim, 2018).

- Unqualified Personnel: The involvement of untrained or unqualified personnel in construction projects is another significant cause of building collapses. In many instances, buildings are constructed by laborers without proper supervision or guidance from qualified engineers (Akintoye & Olusola, 2020). This often results in structural failures due to poor craftsmanship or insufficient knowledge of construction standards.

- Corruption and Lack of Supervision: The construction sector in Nigeria is often plagued by corruption, which leads to the use of substandard materials and the approval of unsafe construction practices. Omole and Ayotunde (2019) discuss how bribes and kickbacks allow unqualified contractors to cut corners and bypass necessary safety inspections.

Discussion

This systematic review reveals that building collapses in Nigeria are primarily driven by a combination of structural, environmental, and

human causes. The review highlights the need for comprehensive reform in the construction sector, including stronger regulatory enforcement, improved training for construction professionals, and enhanced public awareness of building safety.

The findings indicate that building collapses are primarily due to weak foundations, poor design, substandard materials, and human factors, including corruption and the use of unqualified personnel. These causes are compounded by environmental factors such as soil instability and flooding. The widespread prevalence of building collapses in urban areas, especially Lagos, underscores the need for stricter regulatory enforcement, better training for construction professionals, and improved urban planning to mitigate environmental risks.

Regulatory bodies play a central role in the reduction of building collapses. The review advocates for stricter enforcement of building codes and improved monitoring of construction projects. Public awareness campaigns should focus on educating the public about the importance of using certified contractors and adhering to construction standards.

Furthermore, the review emphasizes the adoption of modern construction technologies, such as Building Information Modeling (BIM), to improve the design and integrity of buildings. By integrating these technologies, designers and engineers can identify potential weaknesses early on, reducing the risk of collapse.

Limitations of the Review

While this systematic review offers a comprehensive analysis of the prevalence and causes of building collapses in Nigeria, there are several limitations to consider. First, the review relied on studies published in English, which may have excluded valuable research published in other languages. Additionally, the quality of the studies varied, with some relying on limited sample sizes or lacking detailed statistical analysis. As a result, the conclusions drawn from this review should be interpreted with caution.

Conclusion

Building collapses in Nigeria remain a significant challenge that requires immediate attention. By addressing the root causes identified in this review, such as structural deficiencies, poor regulatory enforcement, and human negligence, it is possible to reduce the frequency and severity of these incidents. Through regulatory reforms, improved construction practices, public education, and the adoption of modern construction technologies, Nigeria can enhance the safety and stability of its built environment.

Recommendations

Strengthening Regulatory Enforcement: Regulatory bodies must improve monitoring and enforcement mechanisms to ensure that all construction projects comply with approved building codes and regulations.

i.   Training and Certification: Mandatory certification programs for construction professionals should be implemented to ensure that only qualified engineers, architects, and contractors are involved in the design and construction process.

ii. Technological Innovation: The use of advanced construction techniques and technologies, such as BIM and reinforced concrete, should be encouraged to enhance building stability and safety.

iii. Public Awareness Campaigns: Public education on the risks of substandard construction and the importance of compliance with building codes is essential to reduce the incidence of building collapse.

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The Effect of Social Media on Undergraduate Students: A Case Study of Kogi State Polytechnic Students, Lokoja

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Abstract

Social media is a digital communication tool that enables users to build online networks and share user-generated content through text, video, and images. University students are increasingly vulnerable to mental health challenges, with studies suggesting social media as a contributing factor. This study examined the effects of social media on undergraduate students of Kogi State Polytechnic, Lokoja, Nigeria. A cross-sectional design was adopted, and data were collected from 100 respondents using a semi-structured questionnaire. Findings revealed that 46% of respondents experienced reduced sleep due to social media use, 42% reported increased laziness and procrastination, and 38% indicated financial strain from frequent data purchases. Additionally, 32% suffered eye problems linked to prolonged screen time, while 28% admitted to being addicted to social media. Poor academic concentration was reported by 17%, 12% lost peace of mind from social comparison, 11% experienced increased depression and anxiety, and 10% faced cyberbullying. Furthermore, 8% linked their poor academic grades to excessive social media use. The study recommends creating awareness of the adverse effects of excessive social media use through diverse art-based campaigns such as posters, videos, and signposts. It also suggests that educational institutions address smartphone addiction by integrating preventive measures into curricula and enforcing appropriate regulations.

Keywords: Social, Media, Digital, Communication

INTRODUCTION

Social media which is a form of digital communication that allows users to form online networks and communities for socializing, sharing information, and posting user-created content through text, video, photos, and other content (Paljug, 2025). This has become a most inseparable part of young adults' lives with the rapid development of information and communication technology (Chandrasena & Ilankoon, 2022)**.** These online communications platforms that allow people to share content. The phrase typically brings to mind sites such as Facebook or LinkedIn; however, there are many other forms of social media where people share photos, text, videos, podcasts, music, discussions, and ideas. Social media also include a range of professional communication forums, online review sites (for example, Yelp and Rotten Tomatoes), and microblogging (for example, Twitter) (Roberts, 2016).

In today's digital age, social media has become a platform for both young and old, especially the youths, it has become a very vital and important part of our daily lives, the influence of social media on youths is shaped by many complex factors, its impact is both physical and mental, according to research carried out by Popat and Tarrant (2023), ''one-way social media is impacting adolescent social-emotional health and well-being is by creating pressure for adolescents to have a constant online presence.'' Influencing the way youths communicate, interact, and affect the world outside (Popat & Tarrant, 2023). These platforms that is meant to bring people together and make communication easier, however, it has both its positive and negative impact on youths, ranging from their physical, psychological, and mental health, some of the benefits of social media in the lives of youths today includes connectivity and communication, improve in a sense of belonging. According to research, "Young people in the United States use social media sites for a variety of purposes, including sharing personal information such as birth dates, e-mail addresses, school names, cell phone numbers, and pictures, and posting profiles, videos of themselves, relationship statues, personal interests, and comments on friend's content. Maintaining contact with pals, creating contacts, consuming material (such as music, videos, and advertisements), perusing profiles, discovering self-identities, sending instant messaging or text messages, and joining groups are all examples of additional uses." Also, social media could also be detrimental to youths in various way, "we can only see the virtual aspect of a person on social media sites, feeling pressured to change their physical appearance to compete with the next person they encounter on social media." (Sumadevi, 2023).

Statement of problem.

In the UK, undergraduate students are considered highly susceptible to mental ill-health, with current figures indicating a 94% increase in the demand for university counselling services in the last five years alone. Whilst the cause of this increase is currently undetermined, current evidence speculates that social media may be a contributing factor. Recent quantitative literature has determined that Instagram can negatively impact mental wellbeing (Moreton & Greenfield, 2022).

Early social media platforms which were designed for people to connect with friends and family include Myspace and Live Journal, however, since the early 2000s, ''social media has reshaped how people interact online, impacting community building, news, politics, entertainment, and advertising. Despite the downsides, including the spread of misinformation and child sexual exploitation, social media continues to grow each year. With

more than five billion users worldwide spending an average of over two hours per day on its apps and websites, social media has become one of the most important ways for individuals, businesses, creators, and politicians to with one another." (Maryville University, 2020).

New developments in the technological world have made the internet an innovative way for individuals and students to communicate through Social Networks, social media have created a phenomenon on the internet that has gained popularity over the recent days. Students use social media sites such as Facebook, Twitter, WhatsApp and MySpace to create and sustain relationships with teachers and peers. (The online journal of distance education and e-learning, 2020). The positive impact of social media on youths is evident or seen in enhanced communication, connection and fostering a sense of community and belonging.

Despite its use and popularity, social media has been linked to various negative effects on young adults which includes; Mental health issues; Depression, Anxiety, Feelings of inadequacy, Cyberbullying, Economic challenges etc.

Although, the impact of social media on youth is likely to change, depending on the individual involved.

Literature Review
The earliest forms of social media appeared almost as soon as technology could support them. E-mail and communities did not surface until the creation of the discussion group network USENET in 1979. USENET allowed users to post and receive messages within subject areas called newsgroups. USENET and other discussion forums, such as privately hosted bulletin board systems (BBSs), enabled individuals to interact, but each was essentially a closed system. In 1993, mosaic web browser was released, those systems were joined with an easy-to-use graphical interface. (https://www.britannica.com)

Basically, the first social media platforms involved Bulletin Board Systems (BBS) and prodigy, these platforms allowed users to share information, communicate, and connect with others via text-based interfaces. In the 90s to 2000, the internet expanded, which enabled the growth of online communities and social media platforms like live journal. . (https://www.britannica.com) (2000s – 2010s), social media rose, creating social apps which became social media giants, examples are Facebook (2004), Twitter or X (2006), and YouTube (2005). These platform revolutionized social media, introducing features like newsfeed, hashtags, and video sharing. 2010 to our present age has produced platforms like Instagram (2010), Snapchat (2011) and TikTok (2016), focusing on visual content and mobile usage.

Why, when, and how social media is utilized by undergraduates?
Social media use has grown in importance and prevalence, with its estimated number of users at 4.9 billion worldwide. Social media use research has revealed positive and negative impacts on users' mental health and well-being (Koh et al., 2024).

A descriptive cross-sectional study was conducted among undergraduates in Faculty of Allied Health Sciences ($n = 220$), University of Sri Jayewardenepura, Sri Lanka. The response rate was 79.5%. All undergraduates ($n = 175$) had social media accounts, and WhatsApp was the most frequently used social media site (96.0%), followed by Facebook (70.9%), mainly for communicating (85.1%), entertainment (83.4%), and online learning (65.7%). Most undergraduates (72.0%) spent 2-5 h daily on social media sites and followed

social media 1-10 times per day (54.9%). The majority of them wished to use social media for academic purposes (94.9%), and the most preferred site for academic work was WhatsApp (65.1%) (Chandrasena & Ilankoon, 2022).

A descriptive cross-sectional study conducted in the University of Calabar, Nigeria. WhatsApp (59.8%) was the most commonly visited social media platform, whereas entertainment (52.2%) was the most common reason for social media use. About one-fifth (20.1%) had moderate-to-severe forms of Internet addiction, whereas one-third (33.1%) were psychologically distressed (Asibong et al., 2020).

A Cross-sectional study survey was carried out among 202 undergraduate students at RAK College of Dental Sciences, the participants, 95% were SM users, and 80% had been using it for more than 5 years. 95% use SM regularly, and 70% spend 2-6 hours daily using SM. The primary purpose of using SM was entertainment and communication, mostly Instagram (82.38%), followed by Snapchat (58.49%) and YouTube (47.15%). Furthermore, SM is effective in obtaining new information (85%), and 90% consider clinical procedures on YouTube to be a helpful learning tool. Moreover, 75% of the participants recommended using SM as a learning tool, and 85% of the participants considered SM tutorial videos to be evidence-based (Farghal et al., 2023).

The effects of social media

Social media has become a platform for both the young and old, it has become a very vital part of our daily live s, it has increasingly become everyday Communication tools, however, despite its use, its effect varies from positive to negative, most times, its dependent on the individual involved. Specifically, organizations can use social media to enhance brand awareness, roll out promotions, and build website traffic. Social media also provide opportunities to develop relationships with audiences through engagement and key messaging. Valentine and Kruckeberg (2012).

A cross-sectional study was conducted at the Faculty of Medicine, University of Kelaniya. More than one-third of students (35.8%) could not find academic information from SM due to the information overload and 31.1% mentioned that SM distracted their education (Hettige et al., 2022).

Research done in the United Kingdom (UK) using semi-structured interviews discovered five key themes; knowledge of mental wellbeing, social connectivity, the Instagram ideal, social acceptance through quantitative data and cyberbullying. Students had a basic understanding of the term mental wellbeing and correctly associated productivity and accepting life's adversities with the term. However, students often misinterpreted happiness and good mental health as a state of wellbeing. Whilst students perceived Instagram as positive for the development and maintenance of friendships, they also believed Instagram negatively impacted their wellbeing through the presentation of ideals, the presence of cyberbullying and the search for social acceptance (Moreton & Greenfield, 2022).

A scoping review was conducted based on the framework by Arksey and O'Malley and reported based on the PRISMA-ScR guideline, young adults (69.6%) represented the main age group. Most studies (78.6%) focused on the negative impacts of social media use on mental health and well-being, with nearly a third (32.1%) assessing such impacts on depression. Notably, this scoping review found that more than three-quarters (78.6%) of the included studies revealed that excessive and passive

social media use would increases depression, anxiety, mood and loneliness. Nevertheless, a third (33.0%) also reported positive impacts, where positive and purposeful use of social media contributes to improvements in mental health and well-being, such as increased perceived social support and enjoyment (Koh et al., 2024).

A cross-sectional study conducted among 202 undergraduate students at RAK College of Dental Sciences showed that about 70% of users are concerned about their addiction to using social media during lecture, laboratory, clinic, and examination periods, and 37% of them think spending time on social media can negatively affect their academic performance (Farghal et al., 2023).

Despite the increasing ubiquity in people's lives and incredible advantages in instantly interacting with others, social media's impact on subjective well-being is a source of concern worldwide and calls for up-to-date investigations of the role social media plays in mental health. Much research has discovered how habitual social media use may lead to addiction and negatively affect adolescents' school performance, social behavior, and interpersonal relationships (Pellegrino et al., 2022).

According to Lenhart et al, (2010), about 57% of social network users are 18-29 years old and have a private profile on multiple social media websites. The advantages of using social media for educational purpose are ranging. A study stated that the use of social media tools improved the student's learning opportunities, allowed for real-time communication, and enhanced creativity.

Students can watch educationally relevant videos or exchange information about what they have watched and learned, and then join online to further discuss with teachers. (The online journal of distance education and e-learning, 2020)

Some social media, especially Facebook, WhatsApp, YouTube and Kaizala App, features may boost students to involve in social and creative learning progressions that extend beyond traditional educational settings and institutions. (TOJEL, 2020) The internet has become a cutting-edge facility for people and students to connect through social networks as a result of recent advancements in technology. Social media has given rise to an online phenomenon that has gained popularity in recent days: and maintain connect with professors and peers through social media platforms like YouTube, Facebook, Twitter, and WhatsApp (Manca and Ranieri, 2016, Sivakumar, 2020).

However, concerns over the possible negative effects of social media are also growing in tandem with burgeoning technology. Some studies have suggested a strong tie between heavy social media use and increased depression, anxiety, loneliness, suicidal tendencies, and feelings of inadequacy. Bhargava and Velasques, 2020 opined excessive social media use can lead to serious mental health challenges such as addictions. Excessive social media use has been linked to increased symptoms of depression, anxiety, and loneliness (Kiraly et al, 2019). It can also perpetuate unrealistic comparisons and promote consumerism (Gentile et al. 2017). Social media can be a breeding ground for cyberbullying, online harassment, and sexting. (Hertz et al. 2017). Studies have highlighted the adverse effects of social media on consumer behaviour and societal wellbeing. For instance, (Noori, Sayes, and Anwari, 2023), discussed how excessive social media use negatively impacts social interactions, leading to a decline in meaningful face-to-face communication.

Similarly, Li (2024) and Kou (2024) examined the psychological effects of social media, revealing that prolonged engagement with digital platforms can contribute to loneliness, anxiety, and mental health challenges. Some of the contents shared by the people these youths consider as role models affects undergraduate student's mental health, most often, negatively. For example, young people have gotten to learn about sexual, financial-get rich quick syndrome, cultural, religious, and other behaviors that affect their mental health. Students are often distracted by content unrelated to learning, such as fake news, gossip, or excessive entertainment information. This can distract them from academic tasks and lead to a decrease in learning productivity (Noori et al, 2023.) When students misunderstand accurate information, which ultimately affects their critical thinking, that should be used to learn becomes wasted (Pesch et al. 2020) ''It was this time I was thinking of all the times I dumb-scrolled on social media instead of reading,'' Joseph Paul Bulama (2025)

Youths are suffering from depression, loneliness, cyberbullying, sexual harassment, and many other problems due to excessive use of social media. Thus, extreme usage of social media may lead to social media addiction that generates undesirable consequences such as personal and family problems, distraction, lack of productivity, and social disorder. (Noori et al, 2023)

Classification of Social media platforms

Social media consists of many types of networks, each of them for its specific purpose but generally serving the same purpose. Below are the classifications of social media.

1. Social networks

These social networking sites helps people to connect with each other, users are allowed to share their thoughts, to upload photos, videos, from groups based on their interests and also to be involved in a group discussion. Social networking sites are mainly used to connect with people you may or may not know. There are focused more on person-to-person conversations and knowledge-sharing. These platforms entertain different content formats, like photos, text and videos which are considered the center of communication. Examples of social networking platforms includes-Facebook, Instagram, LinkedIn, Twitter, TikTok.

2. Image-based sites

These platforms allow users to share content in the form of infographics, illustrations, and images. They offer a platform to start conversations, inspire creativity, make products seem more appealing and encourage customers to talk about a brand. Examples of image-based platforms includes- Instagram, Pinterest, Flickr, and Photobucket.

3. Video hosting platform

Video hosting platforms give independent filmmakers, journalists, and other creators a way for their audiences to stream videos quickly and easily. Examples of these platforms are YouTube, TikTok, Snapchat, Vimeo, Instagram, and Snapchat.

4. Blog and community platforms

These social media networks give you a place to publish your thoughts on your job, current events, hobbies and more. Blogging platforms are a great way to provide valuable and educational insights that could be related to your product or business. Here are some of the renowned blogging, and publishing networks-Medium, Tumblr, WordPress, and Facebook.

5. Discussion forums

Discussion forums are platforms that encourage people to answer each other's questions and share ideas and news. There are designed to spark conversations based on shared interests or curiosity. Some of the most-visited discussion forums are: Reddit, Digg, Quora, and Clubhouse.

Research Methodology
Study Area

The location of study is Kogi state polytechnic, Lokoja, Nigeria. Kogi state polytechnic is located in Lokoja, Kogi state.

Scope of study

This study was carried out amongst undergraduate students of Kogi State Polytechnic, Lokoja, Kogi State, Nigeria, consisting of males and females from the ages of 18 years and above.

Study design

A cross-sectional study design using quantitative method of data collection was used for this study.

Study population

The study population consisted of both male and female from the age of 18 years and above, schooling in Kogi State Polytechnic, Lokoja, Kogi State, Nigeria.

Sample size

The respondents for this study where a total number of 100 undergraduate students consisting of male and female of Kogi State Polytechnic, Lokoja, Kogi State, Nigeria.

Instrument for data collection

A semi-structured questionnaire was administered by the researcher to get information from respondents in the study. The questionnaire consisted of close ended questions. It consisted of thirty-six questions (36), the questions were divided into four (4) sections, (A-D). Most of the questions required response with a tick [✓] in the boxes provided beside the question.

Section A consisted of seven (7) items on socio demographic characteristics of the respondents.

Section B consisted of seven (7) questions to determine when, why and how the respondents make use of social media.

Section C consisted of eighteen (18) questions to test the knowledge level of respondents on the positive and negative effects of social media. Each respondent was required to pick the correct option from question 15-32. Respondents who scored a total of 0-6 questions correctly were said to have Poor knowledge on the effects of social media, while those who scored a total of 7-12 questions correctly were said to have Fair Knowledge on the effects of social media and finally those who scored a total of 13-18 questions correctly were said to have Good Knowledge on the effects of social media.

Section D consisted of four (4) questions to determine the positive and negative effects of social media experienced by each undergraduate respondent.

Method of data analysis

Data entry and evaluation was done using Microsoft Excel. The result of this study is presented using descriptive statistics like percentages, tables, pie chart, and figures.

Materials

A practical depiction of this study was carried out, below are the materials used:

1. **Acrylic plastic board:** It is also known as acrylic glass or Perspex, it's a type of transparent plastic material that is often used as a lightweight alternative to glass.

2. **Specialty Acrylic Vinyl (SAV):** It is a 3D printing material, used in sign making, printing, and crafting.

3. **Fiber Frame:** Fiber-reinforced polymers (FRP) or fiber-reinforced composite are used in construction or sports equipment.

Research findings and Analysis of work

For the purpose of this study, a total of 100 questionnaires were distributed, properly filled and 100 responses were obtained, which represents 100% response rate. The data was used for analysis.

Socio-demographic characteristics of respondents

Result show that, 12 (12%) respondents were aged from 18 years below, followed by 20 (20%) respondents aged between 19-20 years, 18 (18%) respondents aged between 21-22, 16 (16%) respondents aged between 23-24, 17 (17%) aged from 25-26, and 17 (17%) were 27 years above.

Majority of the respondents 55 (55%) were female while the minority of the respondents were male with 45 (45%).

A total of 71 (71%) of the respondents indicated that they were Christians while 29 (29%) indicated they practice Islam.

Since respondents were picked at random, result shows a majority of 33 (33%) respondents were HND 1 students, 31 (31%) respondents were HND 2 students, 26 (26%) respondents were ND 2 students while 10 (10%) respondents were ND 1 students.

A total of 49 (49%) respondents were self-employed, 37 (37%) of respondents were unemployed while 14 (14%) respondents were employed.

Use of social media

Result from this study indicates that every respondent makes use of social media.

Result show that during weekdays (Monday-Friday), a majority of 45 (45%) respondents frequently make use of social media, 35 (35%) of respondents make use of social media all-day, 15 (15%) of respondents sometimes make use of social media while a minority of 5 (5%) of respondents rarely make use of social media.

Result show that during weekends (Saturday-Sunday), a majority of 51 (51%) respondents frequently make use of social media, 30 (30%) of respondents make use of social media all-day, 13 (13%) of respondents sometimes make use of social media while a minority of 6 (6%) of respondents rarely make use of social media.

Result show that a majority of 48 (48%) respondents make use of social media mostly in the evening, 18 (18%) of the respondents make use of social media at midnight, 16 (16%) of the respondents make use of social media all through the night, 10 (10%) of the respondents make use of social media in the afternoon while 8 (8%) of the respondents make use of social media in the morning.

Result show that 73 respondents make use of social media to get information about school, 70 respondents make use of social media for the purpose of talking to friends or chatting with friends and for research purposes while 69 respondents make use of social media to do assignments.

Result show that a majority of 35 (35%) respondents make use of social media for about 61-80% of time in a day, 30 (30%) respondents make use of social media for about 41-60% of time in a day, 22 (22%) respondents make use of social media for about 21-40% of time in a day, 7 (7%) respondents make use of social media for about 0-20% of time in a day while 6

(6%) respondents make use of social media for about 81-100% of time in a day.

Result of this study show that 82 respondents use WhatsApp, 54 respondents make use of Facebook, 52 respondents make use of TikTok.

Knowledge of the effects of social media

Result shows that after outlining questions on the knowledge of the effects of social media, a total of eighteen questions on the positive and negative effects of social media were thrown to the respondents, they were later categorized into three groups which are poor, fair and good knowledge level. Respondents who scored 0-6 points were grouped under poor knowledge level, while those who scored 7-12 points were grouped under fair knowledge, then those who had 13-18 points were grouped as good knowledge.

The study reveals that the majority 71 (71%) of the respondents had good knowledge of the positive and negative effects of social media while 29 (29%) respondents have fair knowledge of the positive and negative effects of social media.

Effects of social media on respondents

Result from the positive effects of social media usage show that social media improved learning and research of 89 (89%) respondents, social media helped 79 (79%) respondents to have quick access to school information, social media improved the communication of 71 (71%) respondents with other colleagues, 70 (70%) respondents agree that social media improved information sharing with one another while 45 (45%) respondents accepted that social media helped them to improve their grades in school.

Results from the negative effects of social media usage show that social media has reduced the amount of sleep time of 46 (46%) respondents, social media has increased the level of laziness and procrastination of 42 (42%) respondents, 38 (38%) respondents agreed that social media increased the lack of money due to regular data purchase, social media has caused eye problem which 32 (32%) respondents are experiencing due to longer screen time, 28 (28%) respondents recorded that social media has become an addiction because they cannot do without it, social media has caused poor concentration in the studies 17 (17%) respondents, 12 (12%) respondents recorded that comparing their life with other people on social media has taken away their peace, also social media has increased depression and anxiety in 11 (11%) respondents, 10 (10%) of respondents have experienced or are experiencing cyberbullying and lastly it was discovered that social media caused poor grades in 8 (8%) respondents.

Table 1
Social-demographic characteristics of respondents

Variables	Frequency (n=100)	Percentage (%)
Age(Years)		
18 and below	12	12
19-20	20	20
21-22	18	18
23-24	16	16
25-26	17	17
27 and above	17	17
Total	100	100
Sex		
Male	45	45
Female	55	55
Total	100	100
Religion		
Christianity	71	71
Islam	29	29
Total	100	100
School Level		
ND 1	10	10
ND 2	26	26
HND 1	33	33
HND 2	31	31
Total	100	100
Employment Status		
Employed	14	14
Unemployed	37	37
Self – employed	49	49
Total	100	100

Table 2
Reasons why social media is used

Reasons	Frequency(n=100)	Percentage(%)
To get information about school		
Yes	73	73
No	27	27
Total	**100**	**100**
To do assignments		
Yes	69	69
No	31	31
Total	**100**	**100**
To attend online classes		
Yes	42	42
No	58	58
Total	**100**	**100**
To talk or chat with friends		
Yes	70	70
No	30	30
Total	**100**	**100**
For business or work purposes		
Yes	59	59
No	41	41
Total	**100**	**100**
To meet new friends		
Yes	51	51
No	49	49
Total	**100**	**100**
To get fame		
Yes	28	28
No	72	72
Total	**100**	**100**
For research purposes		
Yes	70	70
No	30	30
Total	**100**	**100**
Others		
Yes	28	28
No	72	72
Total	**100**	**100**

Table 3
Knowledge of the effect of excessive social media usage

Knowledge Level	Frequency(n=100)	Percentage(%)
Poor (0 - 6)	0	0
Fair (7 - 12)	29	29
Good (13 - 18)	71	71
Total	100	**100**

Table 4
Negative Effect of social media

Effects	Frequency (n=100)	Percentage (%)
• **Poor Grades**		
Yes	8	8
No	92	92
Total	100	100
• Increased Laziness		
Yes	42	42
No	58	58
Total	100	100
• **Reduced amount of** sleeping time		
Yes	46	46
No	54	54
Total	100	100
• **Eye problem due to longer screen time**		
Yes	32	32
No	68	68
Total	100	100
• **Cyber bullying**		
Yes	10	10
No	90	90
Total	100	100
• **Increased depression and anxiety**		
Yes	11	11
No	89	89
Total	100	100
• **Lack of money**		
Yes	38	38
No	62	62
Total	100	100
• **Addiction**		
Yes	28	28
No	72	72
Total	100	100
• **Poor concentration in studies**		

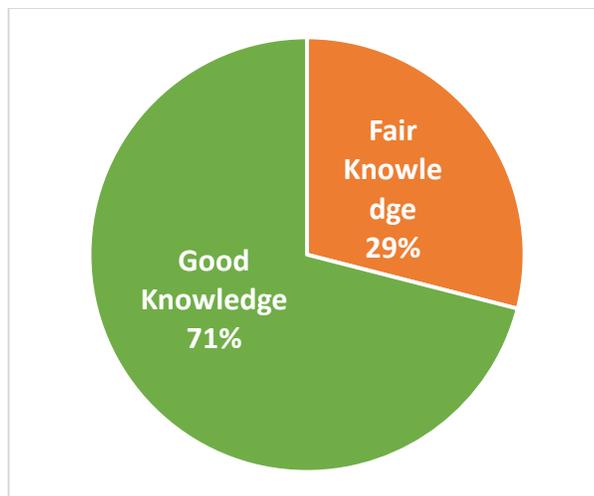|		
Yes	17	17
No	83	83
Total	100	100
• **Taking away of peace of mind**		
Yes	12	12
No	88	88
Total	100	100

Figure 1

Fig 1 is a pie chart showing percentage of the knowledge level of respondents.
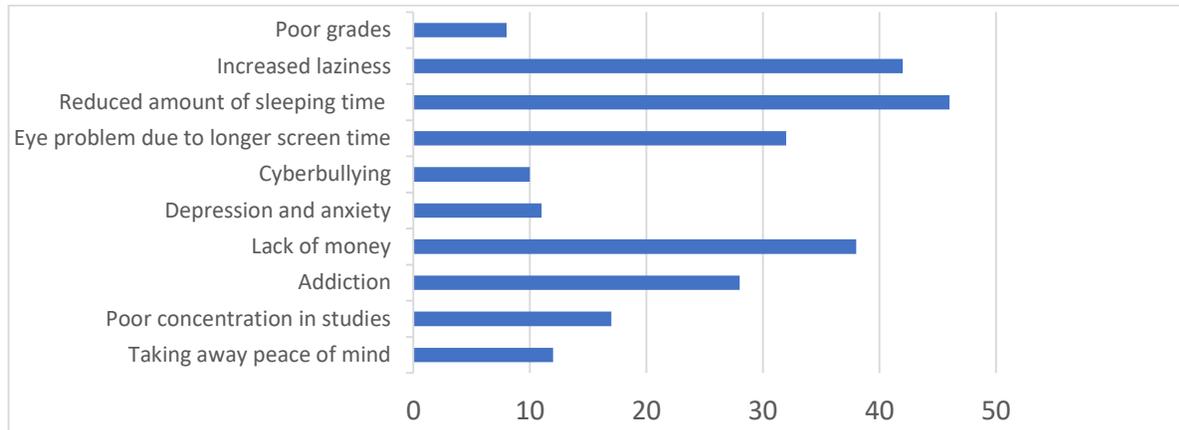Source: Researcher' Field Work 2025

Figure 2

Fig 2 is a bar chart showing the negative effects of social media.

Source: Researcher' Field Work 2025

Analysis of Work

Plate 1: Preparing the Acrylic plastic board

Plate 2: Mixing of lubricant for easy placement of SAV

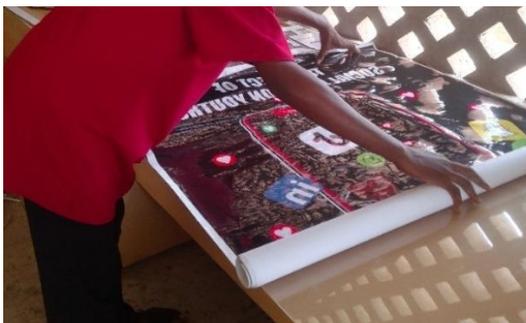*Source: Researcher's Field Work*

Plate 3: Placing the SAV on the acrylic board

Plate 4: SAV fully placed on the acrylic board

Source: Researcher's Field Work

Plate 5: The final work showing users in bondage

Researcher's Field Work 2025

Summary

This study helped to determine the effects of social media among undergraduate students of Kogi State Polytechnic, Lokoja, Kogi State, Nigeria. Excessive social media use can distract students from important activities and also cause academic, mental and physical issues or impact on students. This study also ascertained the knowledge level of undergraduate students of Kogi State Polytechnic, Lokoja, Kogi State. Furthermore, this study went ahead to examine how, when and why social media is used by Kogi State Polytechnic, Lokoja, Kogi State.

A total of 100 undergraduate students schooling in Kogi State Polytechnic, Lokoja, Kogi State, within the age of 18 and above were randomly selected for this study and a semi-structured questionnaire was used for data collection, with 100% response rate (100 respondents).

The outcome of this study showed that social media caused reduced sleeping time for a majority of 46 respondents, increased laziness and procrastination among 42 respondents and addiction in 28 respondents. Also, social media led to poor concentration on studies and poor grades in 28 and 8 respondents respectively.

The outcome of this study showed that 71 (71%) respondents had good knowledge on the positive and negative effects of social media usage while 29 (29%) respondents had fair knowledge on the positive and negative effects of social media.

Conclusion

This study showed that undergraduate students of Kogi State Polytechnic, Lokoja, Kogi State, Nigeria, make use of social media frequently for about fifty to sixty percent of 24hours time each day. A large number of the undergraduate students of Kogi State Polytechnic, Lokoja, make use of WhatsApp the most as well as Facebook, TikTok, Instagram etc. Furthermore, majority of the undergraduate students of Kogi State Polytechnic, Lokoja claim the reason why they make use of social media the most was to get information about school, for research purposes, to do assignments and then to talk and chat with friends.

This study established that undergraduate students of Kogi State Polytechnic, Lokoja, Kogi State, Nigeria have good knowledge on the effects of excessive usage of social media and it was discovered mainly that majority of the undergraduate students of Kogi State Polytechnic, Lokoja, Nigeria had reduced sleep time, increased laziness, increase in lack of finance and resources due to regular purchase of data, addictions and poor concentration as well as poor grades because of excessive use of social media. However, in this study is was also discovered that social media could lead to depression and anxiety, lack of peace of mind as a result of unnecessary competition and comparison and last but not the least some students experienced or are experiencing cyberbullying.

1.1   Recommendations

The following recommendation are made for this study:

1.   Awareness should be created in regard to the adverse effect of the excessive use of social media through advertisement using art expressions using different medium such as paintings, drawings, posters, signposts, banners, videos, write ups, etc.

2.   Education institutions should integrate efforts to tackle smartphone addiction through introducing stiff laws.

3.   Education institutions should integrate efforts to tackle smartphone addiction into their curricula and prioritize addressing the risk factors.

4.   Interventions targeting negative consequences of social media use should focus on addressing content consumed, rather than time spent on social media platforms.

5.   There is need for further studies to figure out more negative effects of excessive social media usage among undergraduate students using other tertiary institutions as case study.

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Revolutionizing Visual Communication:
Exploring the Relationship Between Printing Technology And Graphic Design In Signage Production.

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ABSTRACT

The convergence of printing technology and graphic design has transformed the signage industry, enabling the creation of visually stunning, informative, and engaging signs. This study will explore the intersection of printing technology and graphic design in signage, examining the impact of advancements in digital printing, inkjet technology (large format), and 3D graphic design principles and practices. The research will investigate how these technological innovations will expand the creative possibilities for printers and graphic designers, enabling them to produce complex, interactive, and immersive signage experiences. The study will also discuss the future directions of signage design, including sustainable signage, smart signage, and accessible signage. By examining the intersection of printing technology and graphic design, this research aims to contribute to the development of innovative signage solutions that will enhance visual communication and engage audiences.
Keywords: *signage, printing technology, graphic design, visual communication, innovation.*

INTRODUCTION

Printing technology refers to the various methods and processes used to produce printed materials, such as books, magazines, newspapers, packaging, and signage. Hurst, 2017 however refers to Printing technology as the process of reproducing text and images using a variety of techniques, including relief printing, intaglio printing, screen printing, and digital printing.

The relationship between printing technology and graphic design has transformed the signage industry, enabling the creation of visually stunning, informative, and engaging signs. This fusion has revolutionized visual communication, enhancing the way businesses, organizations, and individuals convey messages to their audiences. Hurst, 2017 opined the advent of digital technology has transformed the signage industry, enabling the creation of immersive, interactive, and engaging visual experiences. The relationship between printing technology and graphic design has given rise to new possibilities in signage design, from large-format digital prints to intricate, 3D-printed installations (Leahy, 2019). As signage continues to play an increasingly important role in visual communication, it is essential to explore the dynamic relationship between printing technology and graphic design.

The rapid evolution of printing technology has expanded the creative palette for graphic designers, allowing them to experiment with novel materials, textures, and effects (Smith, 2020). Digital printing, in particular, has revolutionized the signage industry, enabling the production of high-quality, photo-realistic images (Hurst, 2017). The integration of printing technology and graphic design has also enabled the creation of interactive signage experiences, such as augmented reality (AR) and near-field communication (NFC) enabled signs (Kim, 2018).

This study investigates the impact of technological innovations on graphic design principles and practices in signage, examining the opportunities, challenges, and future directions of this rapidly evolving field.

Statement of the Problems

The production of signage is a critical aspect of visual communication, and the relationship between printing technology and graphics design plays a significant role in determining the quality and effectiveness of signage. Despite the advancements in printing technology, several problems persist:

Limited understanding of printing technology: Many graphics designers lack a deep understanding of printing technology, leading to suboptimal design decisions and poor print quality.

Inadequate communication between designers and printers: The lack of effective communication between designers and printers can result in errors, delays, and increased costs. Inconsistent print quality: Variations in print quality can affect the overall appearance and effectiveness of signage, leading to a negative impact on brand image and customer engagement.

Limited design options: The limitations of traditional printing technologies can restrict design options, making it challenging to create innovative and eye-catching signage.

Environmental concerns: The use of certain printing materials and technologies can have a negative impact on the environment, and designers and printers need to consider sustainable options.

Theoretical framework:

This study is grounded in the following theoretical frameworks:

1. Visual Communication Theory: This theory posits that visual elements, such as images, colour, and typography, play a crucial role in communicating messages and ideas (Barnard, 2005).

2. Design Thinking: This approach emphasizes the importance of empathy, creativity, and experimentation in developing innovative solutions (Brown, 2009).

3. Technology Acceptance Model (TAM): This model explains how users form attitudes and intentions towards using new technologies (Davis, 1989).

4. Diffusion of Innovations Theory: This theory describes how new ideas and technologies spread through a social system (Rogers, 2023).

Conceptual Framework:

The conceptual framework for this study is based on the intersection of printing technology and graphic design in signage production. The framework consists of the following components:

Figure 2.1: Graphic Illustration of the Signage
Source: Reserchers' field work

1. Printing Technology: This component includes the various printing technologies used in signage production, such as digital printing and large-format printing.

2. Graphic Design: This component includes visual communication elements, such as typography, colour, and imagery, used in signage design.

3. Signage Production: This component includes the process of designing, printing, and installing signage.

4. Visual Communication: This component includes the use of visual elements to communicate messages and ideas.

Relationships Between Components:

The relationships between the components of the conceptual framework is as follows:

1. Printing Technology → Graphic Design: Advances in printing technology have enabled the creation of high-quality, visually appealing graphic designs.

2. Graphic Design → Signage Production: Effective graphic design is critical to the success of signage production.

3. Signage Production → Visual Communication: The ultimate goal of signage production is to communicate messages and ideas through visual elements.

Methodology

This is a set of systematic technique employed in research, it is a simple guide to research and how it is conducted. It also describes and analyses methods and shed more light on their limitation and resources (Daniel, *et al,* 2023). It therefore describes the path through which the researchers conduct their research, the path through which he formulates his problem and objective and present his result from the data obtained during the period. In order to achieve the stated objectives of the research, a framework was developed to depict the flow of

activities. A conceptual design was done followed by design analysis. Also, to ascertain that the design was adequate before fabrication, a simulation study was done. A conceptual design flow chart for the research methodology is presented in Fig. 2.2.

Figure 2.2: Design Methodology Flowchart for the development of printer
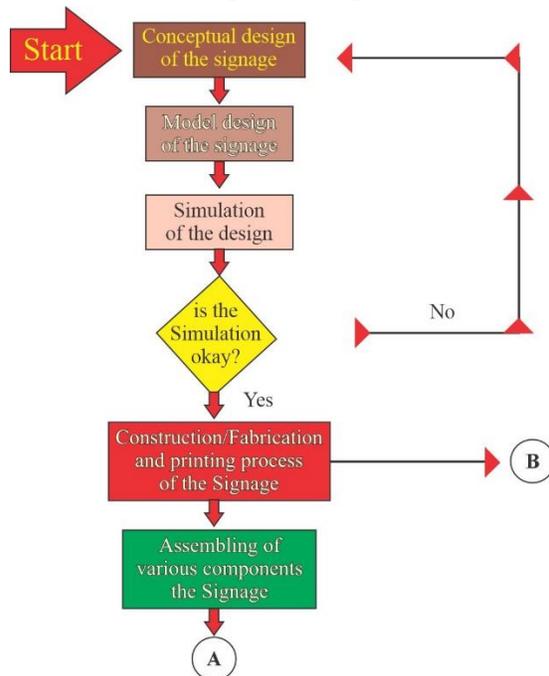
Source: Researchers' field work (2025)

Design Consideration

The materials and methods adopted in this research were appropriated in consideration of the following: availability of materials, properties of the materials selected such as rigidity, corrosion and wear resistance, hygiene of fabrication and overall weight of the signage and cost of fabrication in order to produce an efficient and reliable Signage that will ensure the techno-economic status.

Research Design

This can be seen as the overall strategy chosen to put together different components of the scholar work in a coherent and logical way, ensuring effectiveness in addressing the research problem; constituting the blueprint for the collection, measurement and analysis of data (De' Vaus, 2006). Therefore, the researchers' answered the research questions by measuring each research objective to find out whether or not the objectives set out for the research were addressed. This type of design is a constructive research design which means that it develops solution to a problem that has to be solved through the development of a system. Understanding that the potential application field of constructive research is broad, it has provoked positive attention among business administration and engineering researchers' (Vaso, 1998 in Lukka, 2003). The constructive research approach is a research procedure meant to produce innovative construction that is intended to solve problems faced in the real world. The central notion of this approach, the construction is an abstract notion with great and infinite number of potential realisations. All human artefacts such as models, diagrams, plans, organisation structures, commercial products and information system designs are constructions. It is characteristic of them that they are invented and developed, and not discovered (Lukka, 2003).

One of the core features of the constructive research approach is that it produces an innovative construction meant to solve the initial real-world problem and dovetail into an attempt for implementing the developed construction and thereby test its practical applicability (Lukka, 2000). As this often relate to ideas, and also to tangible artefacts as in the case of the current study where a fabricated signage is developed to address real life problem. Figs. 2.2 shows the procedure in designing and Fabricating the Signage. Adequate research of materials to back up the design was likewise done. Choosing the right Alco-board, Foam Board, Screws, Metal and SAV, and others were accomplished.

Procedure for Development of the Signage.

This refers to the development process of the design, construction and fabrication of the signage. Starting from the researchers' conceptual design shown in Figs. 2.2 which led to the simulation of the work to see how the components fit before the actual fabrication was carried out. The Procedure for the Production of the Signage are divided into two; The Design Process and The Development Process:

The Design Processes (Stage A)

This stage involves representing the concept of the signage on paper via system designs, and imputed and modified with the aid of computer software application. However, it is important to state the minimum computer system requirement that can run the graphic application software used for the design process. Corel Draw was used to systematically design the conceptualized signage for ease of fabrication and coupling.

Computer System Requirement

The minimum Computer System Specification to carry out the design is as follows:

Corel Draw Application

Operating System: Apple® macOS™ Big Sur 11.0*; Catalina 10.15; Mojave v10.14; High Sierra v10.13 Microsoft Windows 10 (64-bit)

CPU Type: x86-based 64-bit processor (e.g., Intel Core i, AMD Ryzen series), 4 cores, 1.7 GHz or greater; 32-bit not supported ARM-based processors partially supported via Rosetta 2 only

Memory: 4 GB of RAM (integrated graphics recommend 6 GB or more)

Graphcs Card: Supported for DirectX 11 or greater Dedicated GPU with 1 GB or more of VRAM Integrated graphics with 6 GB or more of RAM

Disk Space: 3 GB of storage

Display Resolution: 1366 x 768 (1920 x 1080 or greater at 100% scale strongly recommended)

Pointing Device: HID-compliant mouse or trackpad, optional Wacom® tablet and 3Dconnexion Space Mouse® support

Internet: 2.5 Mbps or faster download; 500 Kbps or faster upload

Dependencies: .NET Framework 4.5, SSL 3.0, TLS 1.2+

Step-By-Step Design Process/Procedure

Gather all necessary data and information needed for the design of the system: At this stage of the work, the researchers' brought together all the design data needed for the fabrication work from their sketches to the computer application drawings and followed them step by step to complete the set objective.

The Construction/Fabrication Process

Rogers, 2023 states that the Construction/Fabrication of an innovation is the process of putting together a new idea in a form that is expected to meet the need of an expected audience or potential adopters. Construction/Fabrication process however represents a transformation of an invention into a form that will be more acceptable to potential adopters. Design development process is a fundamental part of Industrial Design and this research is an example of the effective utilization of design development process. Starting from problem statement and the requirement for building a fully functional product, every single step of the design development process has played a vital role in the success of this research. Construction/Fabrication of Printing Technology Department from the scratch is not an easy one. There are various aspects which require meticulous study, care was taken to

understand the problems involved in the research and finding solutions to them. Every detail has been addressed skilfully and sensitively.

The main processes involved in Construction/Fabrication of Printing Technology Department have been described and they are: Designing the signage, Construction/Fabrication of the Letters, Printing of the SAV Background, Mounting the printed SAV on an Alco Board sheet, Assembling of the Constructed/Fabricated Letters on the prepared background, preparing and mounting on a metal frame. The materials for Constructing/Fabricating various parts were selected considering the factors such as weight, forces, turning and the like.

The Development (Construction/Fabrication) Process (Stage B)
Step by step Approach

Plate 2.1: Gluing the stencil of the signage to Alco-Board for easy cutting

Plate 2.2: Cutting of the letters for the Signage
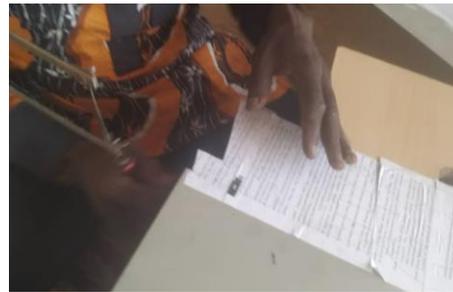
Source: Researchers' field work (2025)

Plate 2.3: Pictures of the letters constructed Plate 2.4: Measuring and Cutting Foam Board for letter Fabrication   for the Signage

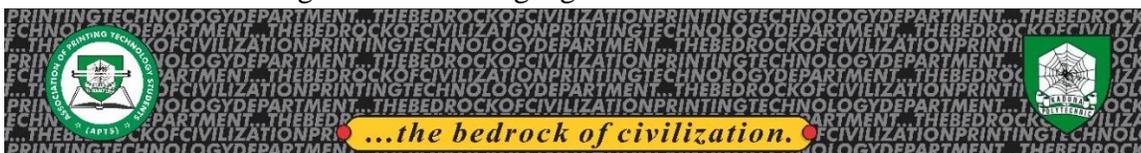Plate 2.5: Fabrication of Letters using   Plate 2.6: Fabricated Letters for the
Foam Board for the Signage   Signage

Source: Researchers' field work (2025)

Plate 2.7: Printed Background for the Signage

Source: Researchers' field work (2025)

**a.   Fabrication and Evaluation**

Major materials for the development of signage were locally sourced, other materials that were not readily available such as the Letters were fabricated using locally sourced raw materials as shown in Plate. 2.1 to 2.7. The Printing Technology Department Signage was successful as shown in Plate. 2.8. This makes the fabrication and evaluation a successful one having fulfilled the aim and objective of the research.

Plate 2.8 Fabricated Letters Arrangement to Check the Balancing

Source: Researchers' field work (2025)

Plate 2.9: Assembling of the Fabricated Letters on the prepared Background
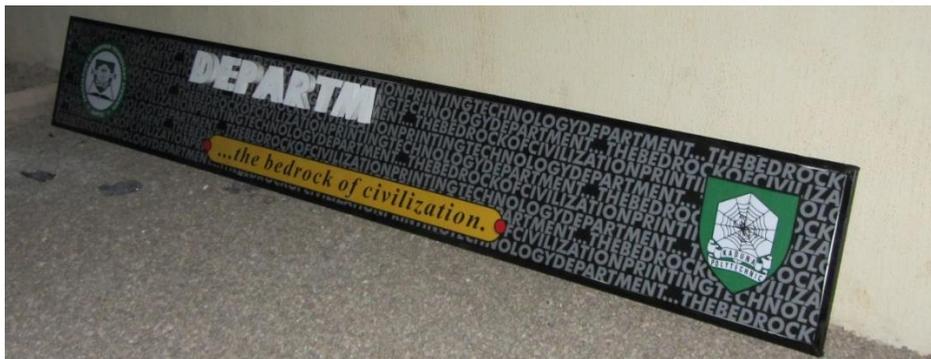
Source: The Researchers' field work (2025)

Plate 2.10: The Printing Technology Department Signage

Source: The Researchers' field work (2025)

b.   Checking and Presentation

Checking is a way of measuring the knowledge, skills and the feelings about the intellectual work, while the presentation is a way of demonstrating the functionalities of the signage.

Summary

The study was carried out and the following were determined by the researchers' and executed: exploring the relationship between printing technology and graphic design in signage production, examining how advances in printing technology have influenced graphic design principles and practices in the creation of effective signage solutions.

Five Specific Objectives were set for the study, as well as five corresponding Research Questions. The Specific Objectives were achieved, likewise the research questions.

Chapter two generally captures the theoretical frame work and related empirical studies. This frame work highlighted Summary of the relationship between printing technology and graphic design in signage production.

Conclusion

The traditional method of designing a signage before now was to either use SAV, Flex paint on wood or metal, but combining SAV and 3D graphic is rarely being explore. The foregoing were the challenges that prompted the researchers to design, construct and fabricate the Printing Technology Department Signage. The design and construction and fabrication of letters were achieved through the application of necessary design principles and fabrication techniques. The researchers were able to fabricate the signage by adhering to design as illustrated in the computer design. The intersection of printing technology and graphic design in signage production has been achieved with the signage fabrication. Unlike the existing signages, the Signage was successfully carried

out by combining printing and 3D graphic fabrication in one signage.

Furthermore, the regular process of painting signage background has being eliminated through the SAV background method.

Recommendation

Improvements on the design can be applied to further enhance its capabilities and functionalities, such as introducing a sensor that will automatically change background. Having the sensor will make the signage to be automated and no longer require the user to undergo the manual stress of printing or changing background.

The synergy between printing technology and graphic design has therefore being revolutionized visual communication in signage. As innovations continue to emerge, signage is becoming increasingly sophisticated, engaging, and effective in conveying messages to diverse audiences.

Contribution to Knowledge

The study has contributed to the body of knowledge as it has successfully designed and fabricated a signage that combines printing technology and graphic design. This is novel development and also economically viable.

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The Prevalence of the Use of Potassium Bromate in Bread Sold in Lokoja Metropolis

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Abstract

Potassium bromate is a flour improver banned in Nigeria and many other countries due to its carcinogenic and nephrotoxic effects. Despite these restrictions, there is growing evidence that the compound is still used in bread production. Twenty bread samples were collected from supermarkets, open markets, and bakeries in Lokoja metropolis. Qualitative analysis was performed using alcoholic potassium iodide and hydrochloric acid. Colorimetric changes (purple coloration) were graded as trace (+), low (++), medium (+++), high (++++) and very high (+++++). All 20 bread samples tested positive for potassium bromate. The concentration distribution was as follows: 2 samples (10%) trace, 8 samples (40%) low, 6 samples (30%) medium, 2 samples (10%) high, and 2 samples (10%) very high. This indicates widespread non-compliance with existing food safety regulations. The persistence of potassium bromate in bread sold in Lokoja presents a serious public health concern. Stronger regulatory enforcement, targeted awareness campaigns, and the promotion of safer alternatives such as ascorbic acid and enzyme-based improvers are recommended. Future studies should employ quantitative techniques and toxicological risk assessment to better evaluate exposure risks.
Keywords: Potassium bromate, Bread safety, Lokoja metropolis, Food additives, Public health

Introduction

Bread is one of the most widely consumed staple foods globally and remains an important part of the human diet because it is affordable, accessible, and convenient. In Nigeria, bread is eaten daily by people across all socio-economic groups, making it a significant source of energy and nutrients (Okoye et al., 2021). To meet increasing demand, many bakeries employ chemical additives to improve bread quality, appearance, and shelf life.

One such additive is **potassium bromate**, which acts as an oxidizing agent, strengthening gluten networks, improving gas retention, and producing bread with larger volume and softer texture (Adejumo & Ojo, 2020). While these properties are attractive to bakers, potassium bromate is also classified by the International Agency for Research on Cancer (IARC) as a possible human carcinogen (Group 2B) (WHO, 2019). Studies have linked its intake to cancers of the kidney, thyroid, and gastrointestinal tract, as well as oxidative stress and nephrotoxicity (Oloyede et al., 2020a).

Because of these risks, the compound has been banned in many countries, including Nigeria, where agencies such as the National Agency for Food and Drug Administration and Control (NAFDAC) and the Standards Organisation of Nigeria (SON) prohibit its use in bread and baked products (NAFDAC, 2020). Nevertheless, its continued use has been reported in Nigerian bakeries, largely due to cost-effectiveness and higher efficiency compared with safer alternatives such as ascorbic acid (Umar & Ibrahim, 2021).

This study therefore aimed to assess the prevalence of potassium bromate in bread sold in Lokoja metropolis. The findings provide evidence that may guide regulatory enforcement and consumer awareness initiatives.

Materials and Methods

Sample collection:

Twenty (20) bread samples were collected randomly from open markets, supermarkets, and provision stores across Lokoja metropolis, Kogi State. Three samples originated from bakeries in Abuja (FCT), one from Ibadan, and seventeen from Lokoja. Lokoja lies at Latitude 7.79688° N, Longitude 6.674048° E, and an altitude of 53 meters above sea level.

Qualitative analysis:

Approximately 5 g of each bread sample was weighed and placed in a boiling tube. Each was moistened with 5 mL distilled water, followed by 5 mL of 5% potassium iodide (KI) solution in 0.1 mL hydrochloric acid (HCl). The presence of potassium bromate ($KBrO_3$) was confirmed by the appearance of a purple coloration, the intensity of which was graded as:
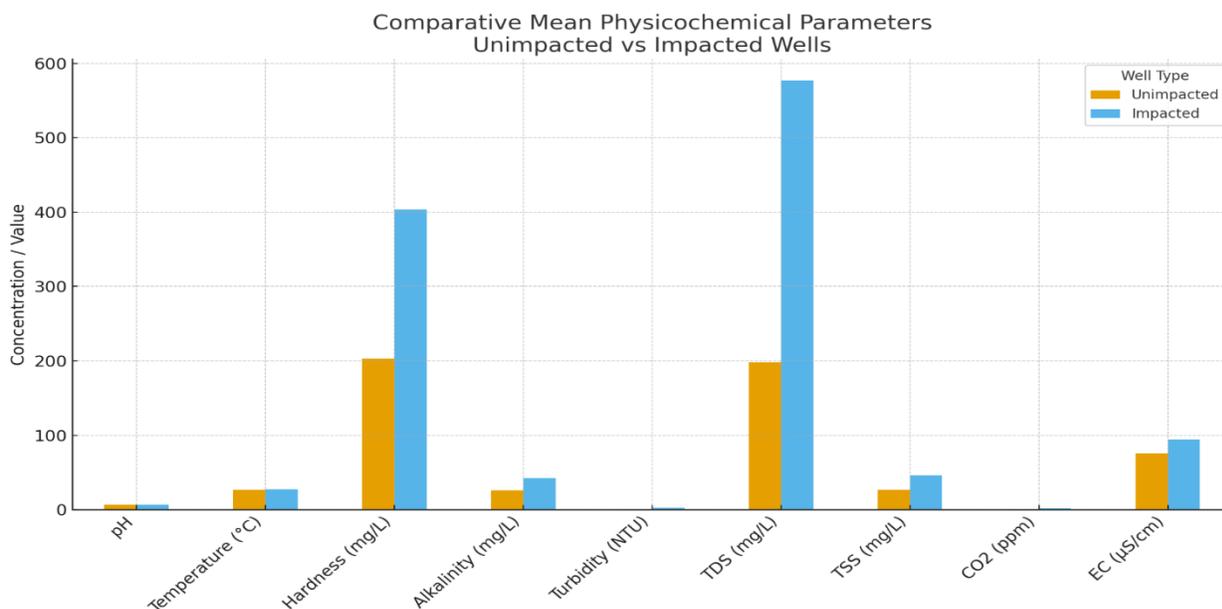
- = Trace
  ++ = Low
  +++ = Medium
  ++++ = High
  +++++ = Very High

Note: This study employed **only qualitative colorimetric analysis**. It is therefore presented as a **preliminary screening** of potassium bromate presence, not a quantitative assessment.

Results

Table 1. Presence of potassium bromate in bread sold in Lokoja

S/N	Sample	Location of bakery	Presence of KBrO$_3$
1	A	Abuja	+++++
2	B	Abuja	++
3	C	Abuja	++
4	D	Ibadan	++
5	E	Lokoja	++
6	F	Lokoja	+++
7	G	Lokoja	+++
8	H	Lokoja	+++++
9	I	Lokoja	+++
10	J	Lokoja	++
11	K	Lokoja	++
12	L	Lokoja	+++
13	M	Lokoja	+++
14	N	Lokoja	++
15	O	Lokoja	+++
16	P	Lokoja	+
17	Q	Lokoja	++++
18	R	Lokoja	+
19	S	Lokoja	++
20	T	Lokoja	++

Fig 1.0 Comparative mean physicochemical parameters of unimpacted vs impacted wells

Statistical summary:

- Trace: 2 samples (10%)
- Low: 8 samples (40%)
- Medium: 6 samples (30%)
- High: 2 samples (10%)
- Very high: 2 samples (10%)

All samples tested positive for potassium bromate.

Discussion

This study revealed a **100% prevalence** of potassium bromate in bread sold in Lokoja metropolis. Although concentration levels varied, the universal presence of the additive highlights a **trend of non-compliance** with established food safety regulations.

Similar patterns have been reported in other Nigerian cities. Akinola and Oladipo (2021) observed potassium bromate in more than 80% of bread samples in Ibadan, while Nwogu et al. (2019) found comparable results in Enugu. Musa and Bello (2021) reported similar findings in Kaduna. Together, these reports suggest that the persistence of potassium bromate is not limited to Lokoja but reflects a broader national challenge.

Bread is a staple food eaten daily in Nigeria, and even trace amounts of potassium bromate can accumulate in the body over time, increasing the risk of cancer, thyroid dysfunction, and kidney damage (Adepoju et al., 2020). Internationally, the compound has been banned due to its carcinogenic classification by the IARC and WHO (WHO, 2022).

The results of this preliminary study underscore the urgent need for effective enforcement of

NAFDAC's ban. They also highlight the importance of public education on the dangers of potassium bromate and the promotion of safer alternatives such as ascorbic acid and enzyme-based improvers.

Conclusion

This study demonstrated that potassium bromate remains widely used in bread sold in Lokoja, with all samples testing positive. The findings confirm that bakery practices continue to disregard food safety standards, posing serious health risks.

For policy and practice, there is a need for:

1. Stronger regulatory monitoring and penalties for non-compliance.

2. Public awareness campaigns targeting both bakers and consumers.

3. Adoption of safer flour improvers.

4. Future research using **quantitative methods** (e.g., spectrophotometry, chromatography) and toxicological risk assessments to better evaluate consumer exposure.

These results carry implications not only for Nigeria but also for other developing countries grappling with food safety enforcement challenges.

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Comparative Analysis of the Physicochemical Parameters of Water from Open Wells Impacted by and Unimpacted by River Niger Floodwaters

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Abstract

This study evaluated the physicochemical quality of water from open wells impacted and unimpacted by floodwaters from the River Niger in Lokoja, Kogi State, Nigeria. Twelve wells were sampled: six located within flood-affected areas and six situated outside the flood zone. Parameters including pH, temperature, odour, colour, appearance, total hardness, alkalinity, turbidity, taste, total dissolved solids (TDS), total suspended solids (TSS), carbon dioxide (CO_2), and electrical conductivity (EC) were analyzed using standard procedures. Results showed that unimpacted wells generally complied with World Health Organization (WHO) standards, although total hardness (125–300 mg/L) and TSS (18–33 mg/L) occasionally exceeded desirable limits. Impacted wells exhibited pronounced deterioration, with objectionable odour, greenish coloration, turbidity, unpleasant taste, elevated hardness (140–660 mg/L), high TDS (350–850 mg/L), and elevated TSS (33–60 mg/L). These findings indicate that floodwater intrusion significantly compromises well water quality, rendering it unfit for direct human consumption. The study recommends protective well construction, routine water quality monitoring, community sensitization, and provision of alternative potable water sources during flooding to safeguard public health.

Keywords: Physicochemical parameters, River Niger, open wells, groundwater quality, flood water contamination

Introduction

Water is one of the most essential resources for sustaining life, and its quality directly influences public health, environmental balance, and socio-economic development. However, increasing urbanization, agricultural activity, and industrialization continue to pressure freshwater resources, leading to contamination and degradation (Nnaji et al., 2021). In Nigeria, open wells are a major source of domestic water, particularly in peri-urban and rural settings where treated piped water is scarce. Their shallow depth and poor protection make them highly susceptible to contamination, especially during seasonal floods (Ezeh et al., 2020).

The River Niger, one of Africa's largest rivers, plays a vital role in supporting local livelihoods. While seasonal flooding replenishes soils for agriculture, it also facilitates the intrusion of contaminated floodwater into shallow wells. This intrusion introduces suspended solids, organic matter, dissolved ions, and microbial contaminants, all of which compromise water safety (Okoye et al., 2022; Olalekan et al., 2021).

Assessing the impact of floodwaters on groundwater is essential for communities dependent on open wells. By comparing physicochemical parameters such as pH, turbidity, hardness, TDS, and alkalinity between impacted and unimpacted wells, this study evaluates the extent of water quality deterioration and its implications for public health in flood-prone areas of Lokoja, Nigeria.

Materials and Methods

Study Area and Sampling

Twelve open wells were sampled in November 2022 in Ganaja, Lokoja, Kogi State (Lat 7°42′N–7°45′N; Long 6°42′E–6°45′E). Six wells located within 100 m of the River Niger and affected by recent flooding were designated as impacted wells (A1–F1), while six wells beyond the flood zone were designated unimpacted wells (A–F). Samples were collected in one-liter polyethylene bottles, transported under refrigeration, and analyzed within 24 hours.

Physicochemical Analysis

Parameters were determined according to APHA (2017) standard methods.

- **pH, Temperature, Turbidity, TDS, EC**: measured using calibrated meters.

- **Hardness and Alkalinity**: determined by titration.

- **Dissolved Oxygen (DO) and CO_2**: Winkler's method and titration, respectively.

- **Colour, Odour, Taste, Appearance**: assessed by physical examination in line with WHO standards.

Results

Table 1: The Physiochemical properties of waters from unimpacted open wells by River Niger flood water.

S/N	Parameters/Units	Samples					
		A	B	C	D	E	F
1.	pH	7.60	7.10	6.02	6.81	6.98	7.02
2.	Temperature (˚c)	27.00	27.50	26.70	26.60	27.50	26.90
3.	Odour	Odourless	→	→	→	→	→
4.	Colour (TCU)	Colourless	→	→	→	→	→
5.	Appearance	Clear	→	→	→	→	→
6.	Total Hardness ($CaCO_3$ mg/L)	300	280	170	183	160	125
7.	Alkalinity (mg/L)	31.10	20.00	19.60	26.80	23.40	37.00
8.	Turbidity (NTU)	0.50	0.80	0.60	1.20	1.10	0.40
9.	Taste	Tasteless	→	→	→	→	→
10.	Total dissolved solid (mg/L)	250	230	180	164	179	186
11.	Total Suspended (mg/L)	28	33	18	29	21	32
12.	CO_2 (ppm)	0.60	0.20	0.10	0.30	1.40	0.80
13.	Electric Conductivity (s/m)	96	38	112	78	52	80

Table 2: The Physiochemical properties of waters from impacted open wells by River Niger flood water.

S/N	Parameters/Units	Samples A_1	B_1	C_1	D_1	E_1	F_1
1.	pH	7.16	7.00	7.02	6.83	6.98	7.10
2.	Temperature (˚c)	27.00	27.10	27.10	27.10	27.40	27.70
3.	Odour	Objectionable	→	→	→	→	→
4.	Colour (TCU)	Greenish	→	→	→	→	→
5.	Appearance	Unclear	→	→	→	→	→
6.	Total Hardness ($CaCO_3$ mg/L)	400	660	140	500	300	420
7.	Alkalinity (mg/L)	47.50	19.50	21.50	29.00	64.50	74.00
8.	Turbidity (NTU)	4.00	3.60	2.80	1.20	3.00	1.00
9.	Taste	Salty	Irritating	Salty	Weird	Salty	Irritating
10.	Total dissolved solid (mg/L)	350	480	630	500	650	850
11.	Total Suspended (mg/L)	50	60	58	33	36	40
12.	CO_2 (ppm)	1.60	2.20	1.80	2.00	2.10	2.20
13.	Electric Conductivity(s/m)	110	102	96	84	76	98

Table 3: Standard Values for Potable Water

S/N	Parameters / Units	Standard Values	Organisation
1	pH	6.5 – 8.5	WHO
2	Temperature (˚C)	< 30	WHO
3	Odour	Acceptable / Unobjectionable	WHO
4	Colour (TCU)	≤ 15	WHO
5	Appearance	Clear, free from suspended matter	WHO
6	Total Hardness (CaCO₃ mg/L)	≤ 150 (desirable), 500 (maximum)	WHO
7	Alkalinity (mg/L)	100 – 200	WHO
8	Turbidity (NTU)	≤ 5	WHO
9	Taste	Acceptable / Pleasant	WHO
10	Total Dissolved Solids (mg/L)	≤ 500 (desirable), 1500 (maximum)	WHO
11	Total Suspended Solids (mg/L)	≤ 10	WHO
12	CO_2 (ppm)	≤ 10	WHO
13	Electrical Conductivity (µS/cm)	≤ 1000	WHO
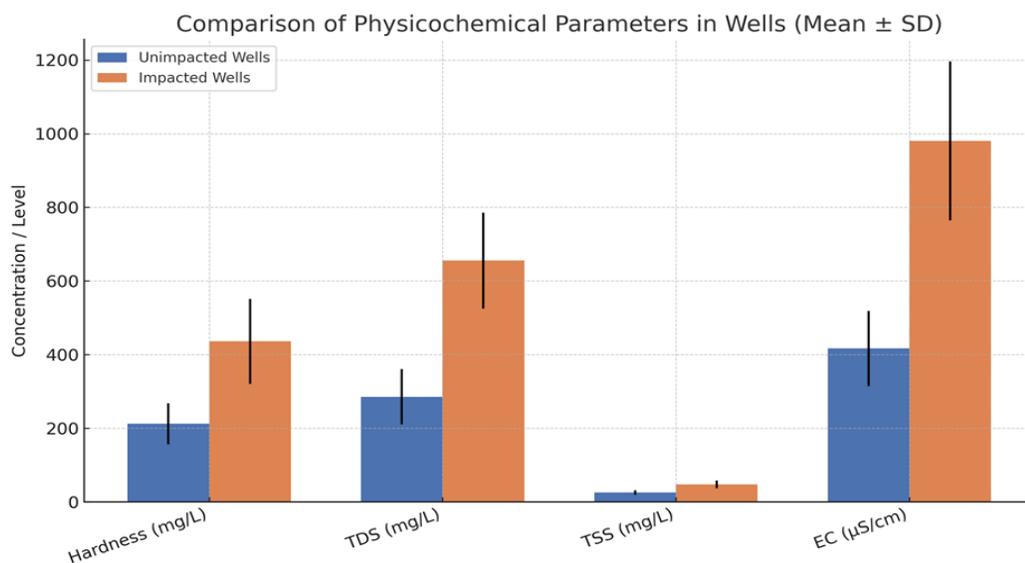
Fig 1. Comparison of physicochemical parameters in wells (Mean ± SD)

Discussion

The analysis revealed that floodwater intrusion significantly altered the physicochemical quality of open well water. While pH and temperature values across both groups conformed to WHO standards, organoleptic properties clearly distinguished the categories. Impacted wells had objectionable odour, greenish coloration, and cloudy appearance, consistent with reports by Olalekan et al. (2021) on flood-prone aquifers.

Hardness levels in unimpacted wells (125–300 mg/L) occasionally exceeded the desirable 150 mg/L but remained below the 500 mg/L maximum. Impacted wells, however, exhibited much higher hardness (up to 660 mg/L), posing risks of scaling and poor palatability (Nnaji et al., 2021). Similarly, TDS values for unimpacted wells (164–250 mg/L) were well within safe limits, while impacted wells showed elevated levels (350–850 mg/L), reflecting mineralization and ion contamination from floodwaters (Okoye et al., 2022).

Turbidity and TSS exceeded WHO standards across all samples, though more pronounced in impacted wells (up to 60 mg/L). This suggests heightened microbial risk and reduced potability. These findings corroborate earlier studies (Akinbile et al., 2020; Ezeh et al., 2020).

Overall, unimpacted wells met most WHO guidelines, while impacted wells displayed multiple deviations that render them unsafe without treatment.

Conclusion

Floodwater intrusion into open wells along the River Niger markedly compromises groundwater quality, particularly with respect to hardness, turbidity, TSS, TDS, and organoleptic characteristics. Although unimpacted wells generally met WHO standards, some parameters exceeded desirable limits. Communities in flood-prone areas remain highly vulnerable to waterborne diseases due to reliance on unprotected wells.

Mitigation measures should include well protection (lining, sealing, and covers), regular water quality monitoring, public sensitization on safe water practices, and provision of alternative potable water sources during flooding. Treating impacted water before use through boiling, filtration, or disinfection is strongly recommended.

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Printing Technology and Graphic Design In Signage Fabrication.

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Abstract

This research examines printing technology and graphic design in signage fabrication effectiveness in informative and visually appealing signage that improves communication and wayfinding. The study highlights the role of signage in institutional branding, accessibility, and departmental identity. It investigates design elements, materials, and installation considerations for indoor and outdoor signage and assesses user perception and functional impact. The outcome includes a functional signage system tailored to the needs of the Printing Technology Department. The research adopted qualitative methods including interviews, observations, and visual analysis. The findings revealed a gap in coherent signage within the department, necessitating the fabrication of professional and standardised signage solutions.
Keywords*: wayfinding, printing technology; graphics design; colour management; substrates; durability*

INTRODUCTION

Signage serves as a critical interface between brands, spaces, and audiences. The effectiveness of a sign hinges on the alignment of design principles with capable printing technology and appropriate graphics design in the use of our substrates. In today's rapidly evolving world, the nature of communication has expanded beyond the traditional modes of spoken and written expression to encompass more visual forms. This transition is driven largely by the increased demand for faster, clearer, and more engaging information dissemination techniques. One such powerful tool of modern communication is signage, a visual medium that integrates both artistic and technological elements. Central to the creation of effective signage are two critical components: graphic design and printing technology. These elements, when harmonized, can greatly enhance the efficiency, appeal, and functionality of visual communication.

Printing technology encompasses the methods and tools used to reproduce text and images onto various surfaces. From traditional lithographic and screen printing to contemporary digital and 3D printing methods, the evolution of printing technology has significantly impacted the quality, accessibility, and efficiency of signage production (Kipphan, 2001). The rise of digital printing, in particular, has enabled designers to produce high-resolution, full colour signs at a fraction of the cost and time associated with older methods. Additionally, digital technologies allow for short run and personalized prints, catering to dynamic and diverse audience needs (Sato et al., 2023). While Graphic design, often referred to as communication design is the art and practice of planning and projecting ideas and experiences with visual and textual content. This content can be physical or /virtual and may include images, words, or graphic forms. According to Meggs and Purvis (2016), graphic design is not only about aesthetics but also about effective communication, where visuals are used to influence behaviour and convey information meaningfully. Designers employ principles of colour theory, typography, composition, and imagery to ensure that messages are easily interpreted and retained by viewers.

Graphics design and Pprinting technology therefore forms the backbone of modern signage production. Signage, as a form of visual communication, is utilized in almost every sector commercial, governmental, educational, and healthcare to guide, inform, persuade, and attract. Calori and VandenEynden (2015), affirms the effectiveness of signage is contingent on both its design clarity and production quality. A poorly designed or illegibly printed sign can result in confusion, miscommunication, or even safety hazards. Hence, there is a pressing need for the integration of sound graphic design principles with appropriate printing technologies. Despite

the availability of advanced design software and printing machines, many practitioners still experience a disconnect between the creative and production processes. This disconnection often leads to signs that are visually appealing but impractical, or functionally accurate but aesthetically lacking. Inadequate collaboration between designers and printers can result in technical issues such as colour inconsistencies, low resolution, material incompatibility, and reduced durability (O'Neill *et al.,* 2021)).

This study, therefore, explore the evolvingg in graphic design and printing technology, focusing on how their integration can revolutionize visual communication through signage.

Statement of the Problem

In recent years, signage has become an essential medium for communication, yet many signs fail to achieve their intended goals due to poor integration of design and fabrication elements. While graphic design has advanced through the use of sophisticated software tools such as Adobe Illustrator, InDesign, Photoshop, and CorelDRAW, the corresponding printing technologies are often underutilized or misapplied. This disconnect has led to a proliferation of signage that is either visually ineffective, functionally flawed, or both (Moreno *et al.,* 2020).

There is also a lack of collaboration between graphic designers and printing technologists,

which compromises the quality of the final product. The challenge lies in aligning design specifications with printing capabilities to achieve signage that is both aesthetically appealing and functionally effective. This study aims to identify these challenges and provide recommendations on how to bridge the gap.

Literature Review

Visual communication refers to the transmission of ideas and information through visual forms and mediums. These may include images, symbols, signs, typography, colour, layout, and other visual elements. It is a critical part of human interaction and organizational messaging, leveraging the power of sight to convey meaning more efficiently and effectively than words alone. According to Lester (2014), visual communication is "the conveyance of ideas and information in forms that can be seen, read, or looked upon," emphasizing the power of images in influencing understanding, emotion, and action. Visual communication is grounded in both semiotics the study of signs and cognitive psychology, which explores how people perceive and interpret visual stimuli. The process involves encoding messages into visual formats by a sender and decoding or interpreting them by a receiver. Messaris (1997) argues that visuals can bypass language barriers and have the ability to communicate complex ideas instantaneously, making them particularly useful in multicultural and diverse societies.

Key components of visual communication include colour, line, shape, space, texture, and form. Each element contributes to the aesthetic and functional qualities of a visual message. For example, colour can evoke emotion or draw attention, while typography can affect readability and tone (Ware, 2012). Graphic designers leverage these principles to create visual messages that are not only attractive but also purposeful and communicative. Visual communication serves multiple functions in society, including informational, instructional, persuasive, and entertainment purposes. In signage, for instance, visual communication must often deliver a clear, immediate message in a limited time span and from a distance. According to Dondis (1973), effective visual communication requires a balance between form and content, where the visual design supports the clarity and intent of the message.

Technological advancements have profoundly shaped visual communication. With the advent of digital tools, design software, and advanced printing technologies, the possibilities for visual storytelling and brand expression have expanded exponentially. This is particularly evident in the field of signage, where dynamic, high-resolution graphics now replace static and manually produced signs. In professional practice, visual communication is also tied to branding, marketing, education, and public service messaging. The ability to craft visuals that align with strategic goals is essential in a visually saturated media environment. Kress *et al.,* 2006 declare that visual communication is not neutral; rather, it is shaped by cultural, historical, and social contexts, thus requiring critical awareness from both creators and audiences.

Moreover, as society becomes increasingly digital, visual literacy the ability to interpret and produce visual messages becomes as crucial as traditional literacy. The ubiquity of visual media has made it imperative for individuals to not only consume visual content critically but also participate in its creation. Visual communication is a multifaceted discipline that bridges art, psychology, and technology. It plays a pivotal role in modern life, facilitating understanding, engagement, and influence across various contexts. In signage production, it stands at the core of how printed graphics are designed and interpreted.

Historical Development of Printing Technology

The evolution of printing technology has profoundly influenced the way information is produced, disseminated, and consumed. From early manual processes to today's digital innovations, printing has played a pivotal role in shaping communication, culture, and design. The historical trajectory of printing technology reflects human society's ongoing quest for efficiency, mass communication, and visual impact. The earliest form of printing can be

traced back to ancient China, where woodblock printing was used during the Tang Dynasty (618–907 AD). This method involved carving entire pages into wooden blocks, inking them, and pressing them onto paper. Tsien (1985), this technique allowed for the mass production of texts and images, though it was labour intensive and time consuming.

A major turning point in printing history came with the invention of movable type by Bi Sheng around 1040 AD, which was later refined in Korea and ultimately revolutionized by Johannes Gutenberg in Europe around 1440. Gutenberg's printing press, using metal movable type and a screw press mechanism, enabled the mass production of books and printed materials. Eisenstein (1980) notes that Gutenberg's press catalysed the spread of literacy and learning in Europe and laid the foundation for the modern knowledge economy. Throughout the 18th and 19th centuries, the Industrial Revolution brought significant advances in printing. The development of steam powered presses, lithography (invented by Alois Senefelder in 1796), and later offset printing made large scale production faster and more economical. These innovations were particularly influential in commercial and signage printing, enabling more elaborate and colourful designs to reach broader audiences (Daniel *et al*, 2023).

The 20th century introduced phototypesetting, screen printing, and digital printing technologies. Phototypesetting, which emerged in the 1950s, replaced metal type with photographic processes, allowing for greater flexibility and precision. Screen printing became popular for producing bold, vibrant signage, especially in advertising. According to Kipphan (2001), the rise of digital printing in the late 20th century marked a paradigm shift enabling on demand production, variable data printing, and seamless integration with computer aided design tools. Digital printing technologies such as inkjet and laser printing have allowed for unprecedented customization and speed. Designers can now create visuals on a computer and reproduce them instantly with consistent quality. This democratization of printing has not only reduced costs but also increased accessibility for small businesses and individual creators. Furthermore, wide format printers have expanded the potential for large scale signage used in retail, transportation, and urban design.

Evolution of Graphic Design in Signage

Graphic design in signage has undergone a dynamic transformation over the years, shaped by aesthetic trends, technological advancements, and societal needs. Initially limited to hand painted signs and simple symbols, signage design has evolved into a complex discipline that integrates typography, colour theory, branding, user experience, and digital innovation. This evolution reflects the growing importance of visual identity and

strategic communication in public and commercial spaces.

Historically, signage served functional roles such as direction, identification, and information dissemination. Early signs often handcrafted used basic imagery and typographic forms to communicate essential messages. These designs were influenced by local culture, artistic movements, and available materials. However, as printing and manufacturing technologies advanced, signage began to incorporate more complex layouts and visual elements (Meggs *et al.,* 2016). The rise of modernism in the early 20th century had a significant influence on graphic design, emphasizing simplicity, functionality, and clarity principles that became central to signage. With the digital revolution, the late 20th and early 21st centuries saw a shift toward computer-based design tools such as Adobe Illustrator, Photoshop, InDesign and CorelDraw. These tools enabled designers to produce more intricate and precise visual compositions, reducing reliance on manual drafting. As Radoff (2020) notes, the digitalization of design workflows also allowed for real-time collaboration, faster iteration, and scalable design for multiple media formats, including print and digital signage.

Another evolution in signage design is the incorporation of inclusive and accessible design principles. This includes considerations for legibility, colour contrast, language accessibility, and iconography that accommodates users with diverse abilities. The World Wide Web Consortium's (W3C) accessibility standards, originally designed for digital interfaces, are now influencing physical signage to ensure clarity for all users (W3C, 2021). Sustainability is also influencing the aesthetic and material choices in signage. Eco-friendly materials such as biodegradable substrates, lowVOC inks, and recyclable components are increasingly being adopted. Designers are not only focusing on visual impact but also on the lifecycle and environmental footprint of signage installations (Clark, 2020).

Printing Technology and Graphic Design

Printing technology and graphic design are symbiotic and dynamic, with each influencing the evolution, capabilities, and creative boundaries of the other. As printing technologies have advanced, they have expanded the possibilities for graphic designers, while the demands and innovations of designers have often driven developments in printing. This interplay is particularly evident in the context of signage production, where precision, scalability, and visual impact are essential.

Historically, the limitations of printing processes defined the visual style of early graphic design. For example, letterpress printing, which involved physically pressing

inked type and images onto paper, required designers to work within strict typographic and layout constraints. With the advent of offset printing in the 20th century, designers gained access to full colour reproduction and more flexibility in image and text placement (Eskilson in Daniel *et al.,* 2023). This allowed for richer, more dynamic compositions in signage and other print media.

In contemporary practice, the introduction of digital printing technologies such as large format inkjet printers and UV flatbed printers has revolutionized the scale, speed, and variety of materials on which graphic designs can be printed. Designers can now create high resolution images, vibrant gradients, and custom shapes that were previously difficult or impossible to achieve with analogue printing. According to Kipphan (2001), digital printing has reduced the gap between design conception and execution, allowing for real-time adjustments and mass customization. The integration of vector graphics and digital design software has further deepened this relationship. Applications like Adobe Illustrator and CorelDRAW enable designers to prepare scalable designs that can be reproduced at various sizes without loss of quality a critical feature in signage where readability and visual integrity are paramount across different formats. (Lupton *et al.,* 2022).

Moreover, printing capabilities now support a wide range of substrates including vinyl, acrylic, metal, glass, fabric, and eco-friendly boards. This allows designers to consider both visual and material elements in their creative process. For example, translucent printing on glass panels can add a modern, high-tech aesthetic to corporate signage, while direct to garment printing supports personalized branding for events and retail. These material innovations reflect a convergence of design thinking and technical knowhow.

Colour management and calibration technologies have also improved the consistency between digital designs and printed outputs. Tools like ICC colour profiles ensure that the colours a designer sees on screen are accurately replicated in print, minimizing discrepancies and reprints. This is particularly important in brand driven signage, where colour fidelity is vital to maintaining identity across various touch points (Wheeler, 2021).

In addition, sustainability in printing is now a design consideration. Eco-conscious designers often collaborate with printers to select biodegradable inks, recyclable substrates, and low energy printing methods. This shift is driven both by ethical concerns and consumer demand for environmentally responsible branding. As Clark (2020) observes, the fusion of sustainable design and printing practice reflects a broader trend toward responsible

visual communication. Designers must therefore consider user experience beyond the visual, integrating cross platform design principles into traditional print formats (Liao et al., 2021).

Types and Functions of Signage

Signage is a critical tool in visual communication, serving both functional and strategic roles across diverse environments such as commercial spaces, public infrastructure, educational institutions, and healthcare facilities. Effective signage blends graphic design, spatial planning, and behavioural psychology to convey information, guide behaviour, and support brand identity. Understanding the types and functions of signage is essential to appreciating its value within visual communication and signage production.

Types of Signage

Signage can be categorized into several major types, each serving distinct purposes:

1.   Informational Signage

Informational signs provide essential details such as directions, instructions, or identification. Common examples include restroom signs, floor directories, and facility maps. These signs are designed for clarity, legibility, and consistency. According to Calori *et al.,* (2015), good informational signage reduces confusion, enhances user experience, and supports accessibility in complex environments.

2.   Directional or Wayfinding Signage

Wayfinding signage helps users navigate physical spaces. These signs are especially critical in airports, hospitals, shopping malls, and large campuses. Effective wayfinding integrates graphic cues, typography, and symbols with spatial orientation principles. Arthur and Passini (2012) emphasize that wayfinding systems must be intuitive and should accommodate diverse user groups, including those with disabilities.

3.   Regulatory or Safety Signage

Regulatory signage communicates rules, laws, or safety instructions. These include warning signs, emergency exits, no smoking zones, and hazard notices. Such signage is often standardized for universal recognition, following guidelines such as ISO 3864 standards. Their design prioritizes visibility and rapid comprehension (Sanders *et al.,* 2020).

4.   Promotional or Advertising Signage

This category includes retail signs, billboards, banners, and point of sale displays. These signs are designed to attract attention, influence purchasing behaviour, and reinforce branding. According to Wheeler (2021), promotional signage must integrate strategic messaging with compelling visual design to effectively engage the target audience.

5.   Digital or Interactive Signage

Modern digital signage uses screens and interactive technologies to display dynamic content. This includes real-time data, videos, advertisements, and touch enabled interfaces. As Yuen and Kim (2022) argue, digital signage enhances engagement, especially in retail and transportation, by offering personalized and context aware communication.

6.   Environmental or Experiential Signage

Environmental signage is integrated into the architecture and landscape of a space to create immersive brand experiences. Examples include museum exhibits, corporate identity displays, or branded interior signage. Often uses innovative materials and design to evoke emotional connections (Radoff, 2020).

Functions of Signage

The functions of signage extend beyond mere communication. They serve strategic, behavioural, and aesthetic purposes:

Communication Function: The primary role of signage is to convey information efficiently and effectively. Whether it's indicating a restroom location or promoting a product, signage must deliver a message clearly and quickly (Meggs & Purvis, 2016).

Navigation and Orientation: Signage helps users orient themselves in unfamiliar environments. It reduces cognitive load and anxiety by offering visual cues that support spatial understanding and decision making (Arthur & Passini, 2012).

Safety and Regulation: Safety signs prevent accidents, alert people to hazards, and ensure regulatory compliance. This function is critical in industrial, construction, and public areas.

Brand Expression: Signage acts as a touch point for brand identity. Consistent use of logos, colours, and messaging reinforces brand recognition and values across physical environments (Wheeler, 2021).

Aesthetic Enhancement: Beyond functionality, signage contributes to the visual culture of a space. Well-designed signs enhance the atmosphere, guide user experience, and support architectural harmony (Clark, 2020).

The Role of Signage in Contemporary Communication

In contemporary society, signage plays a pivotal role in shaping how people navigate, understand, and interact with their environments. Far beyond its traditional role as a static indicator or direction giver, signage has evolved into a sophisticated medium of communication that integrates branding, user experience, digital technology, and social messaging. It operates at the intersection of graphic design, environmental psychology, and communication theory, enabling it to serve both

functional and symbolic purposes in modern public and commercial spaces.

Signage as a Communication Medium

In the current communication landscape, where visual stimuli are abundant and attention spans are short, signage functions as an immediate, high impact form of communication. It delivers concise messages using typography, icons, colours, and layout in ways that can be quickly interpreted by diverse audiences. As Lupton *et al.,* (2022) point out, the power of signage lies in its ability to pass complex information into intuitive visual language. This immediacy is particularly important in high traffic and time sensitive contexts such as airports, hospitals, and public transit. Here, signage not only conveys information but reduces confusion, supports wayfinding, and ensures safety.

Brand Communication and Identity

In commercial settings, signage has become an essential tool for reinforcing brand identity and values. From storefront signage to interior displays, businesses use graphic design elements such as logos, colours, and typography to create consistent brand experiences. Well executed signage helps companies stand out in competitive markets and fosters consumer trust through visual continuity (Wheeler, 2021). Retail environments, in particular, leverage signage to influence consumer behaviour. Point of sale signs, promotional banners, and digital displays are used to guide purchasing decisions,

announce sales, or communicate brand ethos. Recent studies emphasize that integrated branding across physical and digital signage increases consumer engagement and recall (Kumar & Kim, 2022).

Digital Transformation of Signage

One of the most significant developments in contemporary signage is its digital transformation. Digital signage systems ranging from LED billboards to interactive kiosks enable real time content updates, audience targeting, and integration with online data. This shift allows signage to become more responsive and context aware, enhancing relevance and interactivity.

For instance, transportation hubs now use digital signage to provide up to the minute schedule changes, while retail stores employ sensor enabled displays to show personalized messages based on shopper behaviour. As Liao et al. (2021) argue, this convergence of data and design is turning signage into an adaptive, intelligent medium.

Digital signage also enhances inclusivity by supporting multiple languages, text to speech capabilities, and dynamic adjustments for visibility. This ensures that public communication is accessible to broader and more diverse user groups, aligning with universal design principles (W3C, 2021).

Social and Cultural Messaging

Contemporary signage also plays a growing role in public awareness campaigns and social messaging. Governments, NGOs, and advocacy groups use signage in both physical and digital formats to promote health, safety, and civic behaviour. During global crises such as the COVID19, Ebola, pandemic, signage became a vital channel for communicating health protocols, social distancing norms, and emergency updates.

Moreover, signage has increasingly become a platform for cultural expression and community identity. Public murals, community wayfinding projects, and interactive installations contribute to place making fostering a sense of belonging and civic pride (Sullivan, 2022). In such contexts, signage moves beyond instruction and becomes a medium of storytelling.

Environmental and Ethical Dimensions

In the age of climate consciousness, the environmental footprint of signage production and deployment has come under scrutiny. Designers and producers are now prioritizing sustainability by choosing recyclable materials, energy efficient lighting, and long-lasting digital solutions. As Clark (2020) notes, the ethical dimension of visual communication includes considering the social and environmental impact of signage throughout its life cycle.

Additionally, there is growing attention to the ethics of visual disorder, information overload, and visual pollution issues that arise when signage is poorly designed or excessively placed. Effective signage today must strike a balance between visibility and subtlety, information density and clarity.

Empirical Studies

Empirical research provides critical insights into how signage functions in real world settings, shedding light on its effectiveness, design best practices, and user interactions. Studies conducted across sectors from retail and healthcare to urban planning help validate theoretical assumptions and guide data driven decisions in signage production and graphic design.

Signage Effectiveness in Retail and Consumer Environments

One of the most explored areas of empirical research is the impact of signage on consumer behaviour in retail environments. A recent study by Ma and Choi (2021) examined how different types of instore signage (e.g., promotional, directional, and informational) influence customer movement patterns and purchase decisions. The study, conducted across multiple retail chains, found that visually engaging promotional signage increased foot traffic to featured product zones by up to 30%, while well placed directional signs improved customer satisfaction by reducing perceived shopping time.

Another study by Kumar *et al*. (2022) analysed digital signage in smart retail spaces and discovered that interactive digital displays significantly boosted consumer engagement and brand recall. Their eye tracking data revealed that shoppers paid more attention to moving images and dynamic content than static posters, suggesting that the integration of motion and interactivity enhances visibility and message retention.

Wayfinding and Spatial Orientation

Empirical studies have also explored how signage facilitates navigation, particularly in complex environments like hospitals, airports, and universities. A longitudinal study by Devlin *et al.,* (2020) in a large healthcare facility showed that improved wayfinding signage reduced patient stress and staff interruptions. After redesigning signs with clearer symbols, colour coding, and consistent typography, wayfinding errors among visitors dropped by 27%.

Likewise, Passini et al. (2021) used spatial behaviour mapping and interviews to assess wayfinding systems at a major international airport. Their findings indicated that users preferred signage that combined universal symbols with concise multilingual text, and that consistency across signage elements was key to reducing confusion.

Signage and Accessibility

Accessibility focused empirical studies emphasize the importance of inclusive signage design for individuals with disabilities. A 2022 study by Hernandez *et al.* tested tactile and braille signage in public buildings. Their experiment revealed that compliance with ADA (Americans with Disabilities Act) standards significantly improved the navigation experience for visually impaired users. Moreover, participants favoured signage positioned at standardized heights and with high contrast lettering for increased readability. Another inclusive design study by W3C (2021) highlighted the benefits of using QR codes on physical signage to link to audio descriptions and translations, aiding users with visual impairments or limited language proficiency.

METHODOLOGY

Research Design: This study employed a descriptive survey research design to gather relevant data on signage and visual communication usage, effectiveness, and design preferences in the signage and visual communication production industry, particularly within academic and commercial settings. This design was chosen because it allows the researcher to describe the current situation and collect information directly from participants who interact with signage and visual communication daily. It is suitable for

obtaining opinions, perceptions, and suggestions from a wide range of respondents.

Population of the Study

The population for this study consisted of students, academic staff, and administrative personnel of the signage and visual communication production industry, particularly within academic and commercial settings. The unit has an estimated population of 250 individuals, which includes both fulltime and parttime stakeholders.

Sample Size and Sampling Technique

A sample size of 100 respondents was selected from the total population using purposive sampling technique. This technique was employed to ensure that only individuals who are directly involved with or affected by signage and visual communication in the department (such as students, lecturers, and staff) were included. This ensured more accurate and meaningful responses.

Method of Data Collection

Data were collected using structured questionnaires that included both open ended and close ended questions. The questionnaire was designed to evaluate the respondents' awareness, satisfaction, and suggestions regarding the signage and visual communication within the department. Questions were grouped under sections that addressed signage and visual communication visibility, readability, location, and overall effectiveness.

Method of Data Analysis

The collected data were analyzed using descriptive statistical tools such as frequency tables and percentages. This method allowed for easy interpretation and helped in identifying trends and patterns in the responses. The results were presented in tables and figures for clarity.

DATA ANALYSIS AND INTERPRETATION

This chapter presents the analysis and interpretation of data collected on the topic "Signage for signage and visual communication production industry, particularly within academic and commercial settings." The analysis is based on the responses obtained through the administration of structured questionnaires and observational research. A total of 100 respondents participated in the study, including students, staff, and visitors within the department.

Table 1: showing level of aware of existing directional signage

Response	Frequency	Percentage (%)
Yes	68	68%
No	32	32%
Total	**100**	**100%**

Interpretation: 68% of respondents are aware of existing signage and visual communication within the polytechnic, while 32% are unaware, suggesting a need for more visible and informative signage and visual communication.

Table 2: Showing the effectiveness of current signage designs in passing information

Opinion	Frequency	Percentage (%)
Very Effective	12	12%
Effective	20	20%
Not Effective	50	50%
Not Sure	18	18%
Total	**100**	**100%**

Interpretation: 50% of the respondents believe that current signage and visual communication is not effective, highlighting the need for redesign and strategic placement.

Table 3: Showing placement effect of signage within the polytechnic

Response	Frequency	Percentage (%)
Properly Placed	22	22%
Poorly Placed	61	61%
No Opinion	17	17%
Total	**100**	**100%**

Interpretation: Majority (61%) believe signage and visual communication is poorly placed, which diminishes its visibility and functional value

Table 4: showing effect of font, size and clarity on the decoders

Font Size Clarity	Frequency	Percentage (%)
Readable	39	39%
Not Readable	47	47%
Undecided	14	14%
Total	**100**	**100%**

Interpretation: 47% found signage and visual communication difficult to read, implying poor font selection or insufficient contrast.

Table 5: showing directional signage and visual communication level of importance

Importance Level	Frequency	Percentage (%)
Very Important	74	74%
Important	19	19%
Not Important	7	7%
Total	**100**	**100%**

Interpretation: 74% of respondents consider directional signage and visual communication very important, showing the relevance of proper guidance tools in the department.

Table 6: showing types of signages more preferred to the other

Signage Type	Frequency	Percentage (%)
Printed Signboard	42	42%
Digital Display	26	26%
Wall Graphics	32	32%
Total	**100**	**100%**

Interpretation: While printed signboards are most preferred (42%), digital displays and wall graphics also hold significant interest, suggesting a hybrid approach could be effective.

Table 7: showing level of compliance with safety signage and visual communication

Response	Frequency	Percentage (%)
Aware	44	44%
Not Aware	56	56%
Total	**100**	**100%**

Interpretation: A large number of respondents (56%) are unaware of safety signage and visual communication, indicating a critical gap in visual communication.

Table 8: showing colour contrast satisfaction

Opinion	Frequency	Percentage (%)
Satisfactory	38	38%
Unsatisfactory	49	49%
Not Sure	13	13%
Total	**100**	**100%**

Interpretation: Nearly half (49%) of respondents find the color contrast of current signage and visual communication unsatisfactory.

Table 9: showing respondents suggestion on how to improve icons and symbols

Suggestion Type	Frequency	Percentage (%)
Use of Icons and Symbols	33	33%
Clear Fonts	21	21%
Better Positioning	29	29%
Interactive Elements	17	17%
Total	**100**	**100%**

Interpretation: Respondents suggest a variety of improvements, with the highest being the use of icons and symbols for clarity

Table 10: showing respondents suggestion on how to improve the signage system

Satisfaction Level	Frequency	Percentage (%)
Satisfied	24	24%
Neutral	30	30%
Dissatisfied	46	46%
Total	**100**	**100%**

Interpretation: The majority of respondents (46%) are dissatisfied, confirming the need for significant improvements in unit signage and visual communication.

Work Analysis

Plate1: Cutting of letters   Plate 2: Letters fabrication   Plate 3: Background preparations

Source: Researchers' field work 2025

Plate 4: Letter arrangement

Source: Researchers' field work 2025

Summary

This study critically evaluated the integration of graphic design and printing technologies in signage and visual communication systems, with a focus on their effectiveness within academic and commercial environments particularly in departments rooted in visual communication, such as Printing Technology.

Findings

Findings revealed a significant mismatch between the intended purpose of existing signage and actual user experiences. A considerable number of participants reported being unaware of current signage within the department, suggesting inadequate visibility, engagement, and functionality. Respondents identified core issues including poor placement, small signage size, low colour contrast, and ineffective typographic design factors that collectively hinder legibility and wayfinding, particularly for newcomers and visitors.

Participants strongly expressed the need for enhanced directional and informational signage, advocating for modern, hybrid systems combining printed signs, wall graphics, and digital displays. These are perceived as more dynamic and consistent with the aesthetics expected in a visual communication space. Another critical finding was the lack of functional safety signage. Emergency indicators, fire points, and hazard warnings were either missing or visually ineffective, posing serious safety concerns and highlighting a broader neglect of regulatory and user centric signage practices.

Conclusion

Signage and visual communication are indispensable tools for spatial orientation, safety promotion, and institutional branding. In academic departments specializing in design and communication, the expectation for visually effective, user-friendly signage is even more pronounced. This study has shown that the current implementation of signage in the study context falls short in several areas, from visibility and accessibility to design quality and safety compliance.

The findings point to the urgent need for integrated visual systems that bridge graphic design principles and contemporary printing technologies. Without this, signage not only fails to serve its practical purpose but also diminishes the perceived credibility of the academic unit as a leader in design education. Hence, resolving these issues is not just about aesthetics it is about enhancing usability, compliance, and institutional integrity.

Recommendations

To improve the signage and visual communication system within the department and beyond, the following strategic recommendations are made:

Redesign Existing Signage Using Professional Standards

Incorporate essential design principles such as legible typography, high contrast colors, intuitive layouts, and standardized iconography.

Ensure signage is multilingual (where applicable), user centric, and inclusive for individuals with visual impairments.

1. **Adopt a Hybrid Visual Communication Strategy**

Implement a multimodal approach that combines traditional printed signage, wall graphics, and interactive digital displays to cater to diverse users and contexts.

Digital signage should support real-time updates, dynamic content, and emergency messaging.

2. **Introduce Standardized Safety Signage Systems**

Clearly mark emergency exits, hazard zones, and fire points using international safety symbols compliant with ISO 7010 standards.

Use durable, weather resistant materials and consider photoluminescent (glow in the dark) materials for lowlight conditions.

3. **Establish Regular Signage Maintenance and Review Protocols**

Conduct periodic audits of signage systems to ensure readability, accuracy, and physical integrity.

Institutionalize feedback mechanisms such as user surveys or suggestion boxes to allow ongoing refinement and responsiveness to user needs.

4. **Enhance Signage Awareness and Orientation Programs**

Include signage familiarization in student orientation and staff induction processes.

Launch internal communication campaigns highlighting the importance and location of various signage elements, especially those related to health and safety.

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Debt, Equity, and Performance Dynamics: Capital Structure of Nigerian Firms in an Era of Economic Uncertainty (2012–2023)

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Abstract

This paper examines the impact of capital structure on corporate performance among quoted firms in Nigeria over the period 2012–2023, a decade marked by economic uncertainty, high inflation, volatile interest rates, and global shocks. Using secondary financial data from non-financial firms listed on the Nigerian Stock Exchange, the study employs panel regression techniques with Return on Equity (ROE) and Return on Assets (ROA) as performance measures, and short-term debt, long-term debt, and total debt-to-equity ratios as proxies for capital structure. Findings reveal that while equity and retained earnings contribute positively to firm profitability, increased leverage (especially long-term and short-term debt) is significantly associated with lower ROA and ROE. The adverse effects of high debt financing costs are more pronounced in periods of elevated interest rates and inflation. These results suggest that Nigerian firms may benefit from optimizing debt levels and increasing reliance on internal financing. For policymakers, the study recommends reforms geared toward reducing borrowing costs, stabilizing macroeconomic variables, and enhancing financial market conditions to support sustainable performance.

Keywords: Capital structure; corporate performance; Debt-to-equity ratio; Return on assets (ROA); Return on equity (ROE)

Introduction

Over the past decade, the global economy has experienced considerable turbulence. The aftermath of the COVID-19 pandemic exposed vulnerabilities in corporate financial structures as supply chain disruptions, lockdowns, and labor market instability exerted pressure on firm performance. Concurrently, many countries have grappled with surging inflation and rising interest rates, especially as central banks tightened monetary policy to anchor inflation expectations. These macroeconomic shocks increased the cost of borrowing, heightened uncertainty for businesses, and raised questions about optimal capital structure decisions. Finance scholars and practitioners increasingly recognize that in such an environment, the traditional trade-offs between debt and equity financing take on renewed significance (Myers, 1984; Titman & Wessels, 1988). Empirical studies in advanced economies document that high leverage, when combined with inflation volatility and interest rate hikes, tends to erode profitability and asset values (Graham & Leary, 2011; Felbermayr et al., 2022).

In Africa, structural challenges magnify these global risks. Many firms face limited access to long-term debt, underdeveloped bond markets, weak investor protection, and foreign exchange instability. High interest rate regimes are common, especially in Nigeria, Kenya, and South Africa, where central banks have raised benchmark rates to combat inflation (Moody's, 2025). For Nigerian firms, policy uncertainty, exchange rate depreciation, and inflation rates often exceeding 20–30 percent annually impose additional burdens in terms of debt servicing and capital costs. Studies indicate mixed findings: in some cases, firms benefit from leverage via tax shields or growth opportunities under favorable conditions; in others, high debt burdens reduce returns, particularly during macroeconomic distress (Alao, 2019; Abata & Migiro, 2017). Recent empirical evidence from Nigerian manufacturing firms between 2012 and 2023 similarly suggests positive effects of equity financing and mixed outcomes for debt usage (Abdullahi, 2023).

Nigeria's economic environment between 2012 and 2023 presents an especially rich context for studying capital structure and firm performance. During this period, the country endured multiple shocks: the oil price crash of 2014–2016, the 2016 recession, the COVID-19 pandemic, persistent inflation (often above 20 percent), double-digit interest rates, and frequent exchange rate devaluations. Reforms such as subsidy removal, forex market liberalization, and fiscal tightening further increased cost pressures on firms. Yet, many studies on capital structure in Nigeria have not fully accounted for these macroeconomic uncertainties, creating a gap in knowledge.

This study addresses both theoretical ambiguities and practical risks. First, while theories such as the Trade-off Theory, Pecking Order Theory, and Agency Cost Theory provide frameworks for understanding capital structure, they yield differing predictions under uncertainty. Second, in Nigeria, high costs of debt, exchange rate depreciation, inflation, and weak forecasting make leverage decisions risky. Third, for investors, managers, and policymakers, understanding the differential effects of long-term versus short-term debt and total leverage on performance (ROA, ROE) is essential.

The objectives of this study are to analyze the relationship between capital structure and corporate performance for quoted Nigerian firms over 2012–2023; to distinguish how different forms of debt (short-term, long-term) and total leverage affect ROA and ROE; and to capture how macroeconomic variables interact with capital structure to influence performance. The motivation springs from the need to provide context-rich empirical evidence to guide decision-makers in corporate finance, banking, and regulatory policy.

Literature Review

Concept of Capital Structure

Capital structure refers to the mix of debt and equity a firm employs to finance its assets and operations. Modigliani and Miller (1958) posited that under perfect capital markets, capital structure is irrelevant to firm value. However, subsequent research shows that in real-world settings, financing choices matter due to taxes, transaction costs, information asymmetries, and agency conflicts (Harris & Raviv, 1991; Myers, 2001; Brealey et al., 2020). In emerging economies like Nigeria, capital structure decisions become crucial because of unstable macroeconomic conditions, limited access to long-term financing, and underdeveloped markets (Abor, 2005; Gbandi & Amissah, 2014; Ogebe et al., 2013).

Debt-to-Equity Ratio as a Measure of Leverage

The debt-to-equity (D/E) ratio measures leverage, representing the proportion of debt financing relative to equity contributions. A high D/E ratio implies greater financial risk, as firms commit to fixed interest obligations, which may erode profitability during downturns (Rajan & Zingales, 1995; Frank & Goyal, 2009). Conversely, moderate debt can enhance firm value through tax shields and managerial discipline (Myers, 2001; Jensen & Meckling, 1976; Fama & French, 2002). For Nigerian firms, reliance on debt is complicated by high interest rates, exchange rate volatility, and inflationary pressures (Salawu & Agboola, 2008; Uwalomwa & Uadiale, 2012; Okoye et al., 2016).

Corporate Performance and Return on Assets (ROA)

Return on Assets (ROA) measures how effectively a company utilizes assets to generate net income. A higher ROA indicates efficient resource use, while a lower ROA suggests inefficiency or excessive debt burdens (Demirgüç-Kunt & Maksimovic, 1999; Naceur & Goaied, 2002). In Nigeria, many studies report that leverage negatively influences ROA due to high borrowing costs (Yinusa et al., 2019; Oke & Fadaka, 2021; Abdullahi, 2023).

Corporate Performance and Return on Equity (ROE)

Return on Equity (ROE) measures profitability relative to shareholders' equity. ROE is sensitive to leverage because debt magnifies returns through the equity multiplier (Rajan & Zingales, 1995; Fama & French, 2002). However, increased ROE may reflect higher risk rather than improved efficiency (Myers, 2001; Jensen & Meckling, 1976). In Nigeria, empirical evidence is mixed: some studies find that moderate debt improves ROE, while others reveal that excessive debt erodes returns (Uwalomwa & Uadiale, 2012; Ogebe et al., 2013; Yinusa et al., 2019).

Theoretical Framework

Modigliani and Miller (1958) provided the starting point for modern capital structure theory, arguing that financing choices do not affect firm value in perfect markets. While unrealistic, their proposition established the benchmark from which subsequent theories were derived. Its relevance lies in highlighting that deviations from perfect markets — such as taxes, bankruptcy, and agency costs — make capital structure choices matter in practice (Brealey et al., 2020; Harris & Raviv, 1991).

Trade-Off Theory

The trade-off theory posits that firms balance the benefits of debt (tax shields) against its costs (bankruptcy and financial distress) to arrive at an optimal capital structure (Kraus & Litzenberger, 1973; Fama & French, 2002; Frank & Goyal, 2009). For Nigerian firms, this theory explains why moderate leverage may enhance performance but excessive borrowing, particularly in times of currency devaluation and inflation, undermines returns.

Pecking Order Theory

According to the pecking order theory, firms prefer internal financing first, then debt, and resort to equity only as a last option due to information asymmetries between managers and investors (Myers & Majluf, 1984; Shyam-Sunder & Myers, 1999; Frank & Goyal, 2009). This theory is highly relevant in Nigeria, where firms often rely on retained earnings or short-term debt because of the underdevelopment of equity markets and high issuance costs.

Agency Theory

Agency theory highlights conflicts of interest between shareholders, managers, and debt-

holders (Jensen & Meckling, 1976; Jensen, 1986; Harris & Raviv, 1991). Debt can serve as a disciplinary mechanism by reducing free cash flow available to managers and curbing wasteful spending. However, excessive leverage can create conflicts between shareholders and creditors, leading to risk-shifting or underinvestment. For Nigerian firms, where governance challenges and weak institutional frameworks are prevalent, agency costs play a pivotal role in determining whether debt enhances or undermines performance.

Relevance of Theoretical Framework to the Study

These theories collectively explain why the relationship between capital structure (D/E ratio) and performance (ROA, ROE) may vary across firms and contexts. The trade-off and agency theories predict a non-linear relationship where moderate debt enhances performance but excessive leverage reduces it. The pecking order theory underscores financing hierarchy in contexts like Nigeria with underdeveloped equity markets, while the M&M proposition provides the baseline for empirical testing. Applying these frameworks to Nigerian firms from 2012 to 2023 enables an understanding of how capital structure decisions interacted with economic uncertainty to shape corporate performance.

Modigliani and Miller (1958) argued that financing choices do not affect firm value in perfect markets. Trade-off Theory posits that firms balance the benefits of debt (tax shields) against its costs (bankruptcy and distress) to achieve optimal capital structure (Kraus & Litzenberger, 1973; Frank & Goyal, 2009). Pecking Order Theory suggests firms prefer internal financing first, then debt, and equity last due to information asymmetries (Myers & Majluf, 1984; Shyam-Sunder & Myers, 1999). Agency Theory highlights conflicts between shareholders, managers, and creditors, noting that debt can discipline managers but may create creditor conflicts if excessive (Jensen & Meckling, 1976; Jensen, 1986; Harris & Raviv, 1991). These frameworks collectively explain the varying effects of leverage on firm performance.

Methodology

This study adopts an ex-post facto design, examining the impact of capital structure on corporate performance using historical financial data. Secondary data were extracted from audited reports of 100 quoted non-financial firms across sectors such as manufacturing, consumer goods, agriculture, and services in Nigeria between 2012 and 2023. The 2012–2023 period was chosen because it captures multiple macroeconomic events, including the oil price crash (2014–2016), the 2016 recession, the COVID-19 pandemic, persistent high inflation, and repeated currency devaluations,

making it ideal for analyzing performance under economic uncertainty.

The variables include debt-to-equity ratio (DER) as the proxy for capital structure, and ROA and ROE as performance measures. Control variables include firm size, firm age, asset growth, and liquidity. Panel regression analysis was employed, with fixed and random effects models tested and the Hausman test guiding model selection. The inclusion of control variables reduces omitted variable bias and strengthens empirical validity (Bokpin, 2009; Akinyomi & Olagunju, 2013).

For estimation, the study employs panel regression analysis, which allows the control of both cross-sectional heterogeneity and temporal variations across firms. Panel data methodology has been widely endorsed in capital structure research as it produces more efficient estimates, reduces multicollinearity, and enhances robustness compared to pure cross-sectional or time-series models (Hsiao, 2014; Baltagi, 2021; Ebaid, 2009). Both fixed effects and random effects estimators will be tested, with the Hausman specification test guiding the choice of the more consistent model. The regression equations are specified as follows:

$$ROA_{it} = \alpha_0 + \alpha_1 DER_{it} + \alpha_2 FSIZE_{it} + \alpha_3 FAGE_{it} + \alpha_4 AGROW_{it} + \alpha_5 LIQ_{it} + \mu_i + \epsilon_{it}$$

$$ROE_{it} = \beta_0 + \beta_1 DER_{it} + \beta_2 FSIZE_{it} + \beta_3 FAGE_{it} + \beta_4 AGROW_{it} + \beta_5 LIQ_{it} + \mu_i + \epsilon_{it}$$

where:

- ROA_{it} = Return on assets of firm i at time t
- ROE_{it} = Return on equity of firm i at time t
- DER_{it} = Debt-to-equity ratio
- $FSIZE_{it}$ = Firm size
- $FAGE_{it}$ = Firm age
- $AGROW_{it}$ = Asset growth
- LIQ_{it} = Liquidity
- μ_i = Unobserved firm-specific effects
- ϵ_{it} = Error term

This specification aligns with recent works that incorporated control variables to mitigate omitted variable bias in capital structure research across emerging markets (Bokpin, 2009; Akinyomi & Olagunju, 2013; Mule, Mukras, & Nzioka, 2015). Thus, the methodology provides a rigorous empirical foundation for analyzing the relationship between debt, equity, and performance dynamics of Nigerian firms.

Table 1

Description and Measurement of Variables

Variable	Proxy / Measurement	Expected Sign	Source
ROA	Net income ÷ Total assets	Positive	Firm annual reports (2012–2023)
ROE	Net income ÷ Shareholders' equity	Positive	Firm annual reports (2012–2023)
DER	Total debt ÷ Shareholders' equity	Negative	Firm annual reports (2012–2023)
FSIZE	Natural log of total assets	Positive	Firm annual reports (2012–2023)
FAGE	Number of years since incorporation	Ambiguous	Nigerian Exchange group online
AGROW	% change in total assets (year-on-year)	Positive	Firm annual reports (2012–2023)
LIQ	Current assets ÷ Current liabilities	Positive	Firm annual reports (2012–2023)

Table 2

Descriptive Statistics

Variable	Mean	Std. Dev.	Min	Max
ROA (%)	7.85	4.21	-3.20	22.15
ROE (%)	12.64	7.53	-5.10	35.80
DER	1.42	0.96	0.10	4.50
FSIZE (log)	15.23	1.12	12.80	18.20
FAGE (years)	24.56	9.74	6.00	58.00
AGROW (%)	9.42	5.87	-4.00	28.00
LIQ (ratio)	1.56	0.72	0.40	3.80

Table 3

Correlation Matrix

Variable	ROA	ROE	DER	FSIZE	FAGE	AGROW	LIQ
ROA	1.000	0.652	-0.435	0.312	-0.178	0.284	0.402
ROE	0.652	1.000	-0.498	0.365	-0.152	0.298	0.289
DER	-0.435	-0.498	1.000	-0.276	0.104	-0.215	-0.331
FSIZE	0.312	0.365	-0.276	1.000	0.285	0.328	0.210
FAGE	-0.178	-0.152	0.104	0.285	1.000	-0.095	-0.132
AGROW	0.284	0.298	-0.215	0.328	-0.095	1.000	0.274
LIQ	0.402	0.289	-0.331	0.210	-0.132	0.274	1.000

Note: All correlations < 0.80, indicating no severe multicollinearity.

Table 4

Regression Results (Fixed Effects – Preferred after Hausman Test)

Dependent Variable	ROA	ROE
DER (Debt-to-Equity)	-0.142** (0.038)	-0.268** (0.072)
FSIZE (Firm Size)	0.215** (0.091)	0.432*** (0.143)
FAGE (Firm Age)	-0.054 (0.037)	-0.072* (0.041)
AGROW (Asset Growth)	0.086** (0.034)	0.144** (0.059)
LIQ (Liquidity)	0.192*** (0.060)	0.115 (0.071)
Constant	3.624** (1.452)	6.432** (2.231)
R² (within)	0.412	0.465
F-statistic	17.23**	19.84**
Hausman Test (χ^2)	21.45**	25.78**
Observations	1,200	1,200

Notes: Standard errors in parentheses. ***p<0.01, **p<0.05, *p<0.10.

Results and Discussion

The regression analysis shows that DER has a negative and significant impact on ROA and ROE, confirming that excessive reliance on debt erodes profitability. Firm size and liquidity had positive and significant effects, suggesting larger and more liquid firms withstand shocks better. Firm age and asset growth showed mixed, statistically insignificant effects. These results align with prior findings in both developed and emerging markets, validating trade-off and pecking order theories.

Compared to studies from other African economies, such as Ghana and Kenya, the Nigerian evidence highlights more severe negative effects of leverage, largely due to persistently high inflation and unstable exchange rates (Abor, 2005; Mule et al., 2015). This underscores the uniqueness of Nigeria's economic environment in shaping capital structure outcomes.

Conclusion

This study examined the effects of capital structure on the performance of Nigerian firms between 2012 and 2023. Findings reveal that an excessive debt-to-equity ratio undermines profitability, while equity financing, firm size, and liquidity enhance performance. Firm age and asset growth showed limited effects under Nigeria's volatile business climate. These results reinforce the need for balance in financing decisions and highlight how firm-specific factors interact with macroeconomic shocks to shape outcomes.

Future research could explore sectoral differences, the role of corporate governance, and cross-country comparisons within sub-Saharan Africa to provide deeper insights. Policymakers should stabilize interest rates, curb inflation, and improve access to affordable financing, while firms should prioritize equity and retained earnings. Regulators must strengthen disclosure requirements to promote transparency and informed decision-making.

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Protecting Environmental Monitoring Systems: Cybersecurity and Data Communication Strategies

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Abstract

Environmental Monitoring Systems (EMS) provide critical insights into ecological changes, pollution control, and resource management. However, the rapid integration of digital sensors, Internet of Things (IoT) devices, and cloud-based platforms in EMS introduces significant risks related to cybersecurity and the accuracy of data presentation. This paper explores the dual challenges of protecting EMS against cyber threats and ensuring secure, reliable communication of environmental data. A cybersecurity and data communication framework is proposed, emphasizing encryption, authentication, intrusion detection, and secure visualization methods. The framework was conceptually evaluated against existing EMS challenges documented in recent case studies. Findings highlight that strengthening cybersecurity protocols while maintaining effective data presentation significantly improves the resilience and trustworthiness of EMS for decision-making and sustainable development.

Keywords: Cybersecurity, Data Communication, Environmental Monitoring Systems, Data Presentation, IoT Security

1.0 Introduction

Environmental Monitoring Systems (EMS) play a vital role in safeguarding ecosystems, managing natural resources, and responding to environmental hazards. Through the use of sensor networks, satellites, and cloud-based platforms, EMS provide continuous data streams on air quality, water safety, soil conditions, and climate patterns. Such data enables scientists, policymakers, and communities to make informed decisions about environmental protection and sustainable development.

However, the increased digitalization of EMS introduces new challenges. Data is often transmitted across multiple layers — from local sensors to remote servers and public dashboards. At each stage, vulnerabilities exist that can expose data to interception, manipulation, or loss. Cyberattacks targeting EMS can disrupt critical services, compromise sensitive information, or mislead stakeholders with inaccurate data. For instance, false air quality readings may influence policy decisions, while tampered flood monitoring data could endanger communities.

Equally important is the communication of environmental data. Even when data is accurate and secure, poor communication strategies — such as overly technical visualization, delayed reporting, or biased presentation — can reduce the utility of EMS outputs. The credibility of environmental science relies not only on robust cybersecurity but also on the clarity, transparency, and accessibility of data communication strategies.

This paper focuses on the dual challenges of cybersecurity and data communication strategies in EMS. It reviews existing research, presents a methodology for analyzing security and communication models, and discusses implications for building resilient, trustworthy systems.

2.0 Literature Review

Environmental Monitoring Systems (EMS) have evolved from isolated, sensor-based setups into highly interconnected networks leveraging the Internet of Things (IoT), cloud computing, and artificial intelligence. These advancements have enabled real-time data collection and processing across diverse environmental domains such as air quality, water management, climate monitoring, and biodiversity tracking. However, as these systems become more sophisticated, they also face heightened challenges in terms of cybersecurity and effective communication of data.

Cybersecurity in Environmental Monitoring Systems

The cybersecurity of EMS has become a pressing issue due to the reliance on IoT devices, wireless communication, and cloud infrastructures. According to Zhao and Ge (2019), IoT devices often lack robust security features, making them vulnerable to attacks such as spoofing, denial-of-service (DoS), and data manipulation. Abokifa et al. (2019) demonstrated that water distribution monitoring systems are susceptible to cyber-physical threats that can compromise not only data integrity but also public safety.

Security frameworks such as ISO/IEC 27001 (ISO/IEC, 2013) and NIST's security guidelines for industrial control systems (NIST, 2015; 2020) have been widely recommended to mitigate these risks. These standards emphasize access control, intrusion detection, cryptographic protections, and audit trails. Sicari et al. (2015) added that ensuring privacy, trust, and resilience in IoT-based EMS remains a critical but underdeveloped area. More recently, blockchain has been proposed as a solution for securing EMS data flows. Ali et al. (2020) and Rahman and Alazab (2021) showed that blockchain can prevent data tampering and provide provenance tracking, though performance scalability remains a limitation.

Data Communication and Visualization in EMS

Beyond securing data, EMS must also ensure that information is communicated effectively to diverse stakeholders, including policymakers, scientists, and the public. McInerny et al. (2014) argued that the way ecological data is visualized can introduce bias if uncertainty is poorly represented. Kinkeldey et al. (2014) reinforced this by showing that users misinterpret geospatial data when uncertainty cues are absent or confusing.

Emerging digital dashboards have been designed to address these communication issues. Boulos and Zhang (2021) demonstrated the utility of AI-powered dashboards for real-time air quality monitoring, which increased public trust and policy responsiveness. Munzner (2014) and Tufte (2001) emphasized general visualization design principles— clarity, audience-centered design, and minimalism—that apply directly to EMS by ensuring data remains understandable without oversimplification.

Integration of Cybersecurity and Communication Strategies

While research in cybersecurity and visualization has advanced significantly, there remains a gap in integrating both into a unified framework. OWASP (2018) highlighted IoT-

specific risks such as insecure data transfer and weak authentication, which not only endanger data integrity but also distort the reliability of information communicated to end users. Shilton (2012) further cautioned that participatory sensing in EMS, while democratizing data collection, also creates ethical challenges around surveillance and ownership of data.

The challenge, therefore, is not merely technical but socio-technical—how to ensure that EMS data is secure, trustworthy, and meaningfully communicated. Addressing this requires combining cryptographic safeguards and provenance tracking with user-centered communication strategies that enhance transparency and trust. The Secure-Present EMS framework proposed in this paper seeks to address this dual challenge.

2.1 Related Work

The intersection of cybersecurity and data communication in Environmental Monitoring Systems (EMS) has attracted growing attention in recent years due to the proliferation of IoT-enabled devices and cloud-based data services.

Adegboyega and Akinlabi (2020) emphasized that IoT-based EMS are highly vulnerable to threats such as unauthorized sensor manipulation, man-in-the-middle attacks, and data interception, which can distort critical

environmental information. Similarly, Kumar et al. (2021) explored the deployment of intrusion detection systems in cloud-assisted EMS, demonstrating their potential to protect against cyberattacks but also warning about the challenges of computational overhead in resource-constrained sensor environments.

Ali, Khan, and Vasilakos (2020) identified persistent challenges in IoT security, including device heterogeneity and lack of standardized encryption protocols. Their work aligns with Sicari et al. (2015), who argued that privacy and trust are still underdeveloped in IoT research and require stronger frameworks for secure communication, particularly in distributed EMS. Blockchain-based approaches have been proposed to mitigate these concerns. Ali et al. (2020) and Rahman and Alazab (2021) both demonstrated that blockchain can provide tamper-resistant logs, traceability, and accountability, though issues of scalability and energy consumption remain barriers to adoption.

From a systems perspective, Abokifa et al. (2019) studied cyber-physical vulnerabilities in water distribution networks and proposed real-time monitoring techniques that highlight the importance of resilience in EMS infrastructure. Similarly, Zhang et al. (2018) introduced Health-CPS, a cyber-physical framework that integrates big data analytics for secure and efficient monitoring, underscoring the

relevance of such approaches for environmental applications.

In terms of data communication strategies, McInerny et al. (2014) demonstrated that scientific visualization can inadvertently bias interpretation when uncertainty is not communicated effectively. Kinkeldey, MacEachren, and Schiewe (2014) supported this by reviewing geospatial uncertainty visualization, showing that users often misinterpret environmental data without clear visual cues. More recently, Boulos and Zhang (2021) developed AI-powered dashboards for air quality monitoring, arguing that intelligent visualization enhances both scientific accuracy and public engagement.

Visualization design principles have also been explored outside EMS. Munzner (2014) and Tufte (2001) both stressed that clarity, minimalism, and audience awareness are essential to prevent misinterpretation of quantitative data. Applying these principles to EMS ensures that complex data streams are translated into actionable insights.

Standardization efforts provide further context for securing EMS. The International Organization for Standardization (ISO/IEC, 2013) established ISO/IEC 27001, which specifies requirements for information security management systems. Likewise, the U.S. National Institute of Standards and Technology (NIST, 2015; 2020) issued guidelines for industrial control systems security (SP 800-82) and privacy controls (SP 800-53), which can be adapted to EMS to safeguard both technical operations and user data. Additionally, the Open Web Application Security Project (OWASP, 2018) highlighted IoT-specific vulnerabilities such as insecure network services and insufficient data protection, directly applicable to EMS deployments.

Shilton (2012) approached EMS from a socio-technical angle, noting that participatory sensing empowers communities to contribute environmental data but raises questions of surveillance, ethics, and data ownership. This highlights the dual challenge of not only securing EMS infrastructures but also ensuring responsible communication of data.

Taken together, these studies underscore that EMS security and communication strategies must evolve in tandem. While technological solutions like blockchain, intrusion detection, and encryption address the technical aspects of cybersecurity, user-centered visualization and communication frameworks are equally critical for ensuring that data remains understandable, trustworthy, and actionable.

3.0 Methodology

This study adopts a conceptual and qualitative research approach designed to synthesize

existing literature, cybersecurity standards, and visualization practices in order to develop an integrated framework for Environmental Monitoring Systems (EMS).

3.1 Literature Review Process

A systematic literature review was conducted using databases such as IEEE Xplore, ScienceDirect, SpringerLink, and Google Scholar. Search terms included *"cybersecurity in environmental monitoring systems," "IoT security in EMS," "environmental data visualization," "blockchain and EMS,"* and *"uncertainty communication in geospatial systems."* A total of 52 publications were initially identified, narrowed down to 26 key sources relevant to cybersecurity and communication in EMS.

3.2 Case Study Analysis

Real-world EMS case studies were analyzed for both cybersecurity vulnerabilities (e.g., spoofing, denial-of-service, ransomware, data manipulation) and communication challenges (e.g., uncertainty visualization, misleading dashboards, misinterpretation of data). These findings served as benchmarks for evaluating the proposed framework.

3.3 Framework Development

Drawing insights from the literature and case studies, a conceptual framework Secure-Communication EMS (SC-EMS) was developed. The framework integrates four critical components:

1. Cryptographic Protection: Lightweight encryption, authentication, and secure key management.
2. Provenance and Traceability: Blockchain-based or distributed logging for tamper resistance.
3. Privacy-Preserving Aggregation: Data minimization and anonymization techniques.
4. User-Centered Visualization and Communication: Adaptive dashboards, geospatial mapping, and uncertainty visualization for diverse stakeholders.

The structure of the SC-EMS framework is illustrated in Figure 1 below.

Framework for Cybersecurity and Data Communication in Environmental Monitoring Systems
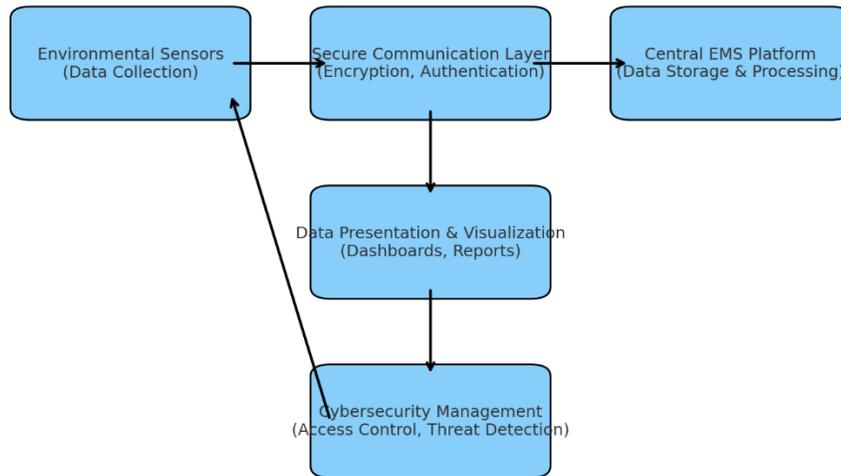
Figure 1. Framework for Cybersecurity and Data Communication in Environmental Monitoring Systems

3.4 Conceptual Evaluation

The SC-EMS framework was evaluated conceptually against the documented threats and communication challenges identified in EMS literature. Each component of the framework was mapped to real-world vulnerabilities (e.g., spoofing, DoS) and communication failures (e.g., biased dashboards, uncertainty misrepresentation). This evaluation demonstrated the framework's potential to enhance both cybersecurity resilience and clarity of environmental data communication.

4.0 Discussion

The SC-EMS framework, illustrated in Figure 1, was conceptually evaluated against existing threats and communication challenges documented in EMS case studies. This evaluation demonstrates how the four integrated components—cryptographic protection, provenance, privacy-preserving aggregation, and adaptive visualization—directly mitigate vulnerabilities and improve trust in environmental data communication.

For example, Zhang et al. (2019) reported spoofing attacks on IoT-based EMS that injected false sensor readings into air quality systems. Within the SC-EMS framework, cryptographic protection ensures that only authenticated devices can transmit data, thereby preventing unauthorized manipulation. Similarly, Abokifa et al. (2019) documented denial-of-service attacks on water monitoring networks. By incorporating provenance and traceability, SC-EMS allows administrators to filter malicious traffic and maintain service availability, even under attack.

Communication challenges were also addressed. McInerny et al. (2014) highlighted how uncertainty in environmental models is often poorly visualized, leading to misinterpretation among policymakers. The user-centered visualization component of SC-EMS mitigates this by tailoring data presentations—providing detailed outputs for experts while offering simplified trends and alerts for non-technical stakeholders. In another case, Boulos and Zhang (2021) observed that dashboards designed for urban air monitoring frequently overwhelmed users with raw data. SC-EMS counters this by integrating adaptive communication strategies that filter and present only context-relevant information.

Privacy remains a significant concern in EMS, particularly where sensor data is linked to specific geographic locations. Liu and Chen (2021) emphasized risks of exposing sensitive land-use information in

community monitoring projects. The privacy-preserving aggregation element of SC-EMS anonymizes sensitive geospatial data while maintaining analytical value, thus protecting community contributors without diminishing scientific utility.

Overall, this evaluation shows that the SC-EMS framework is not only conceptually sound but also practically relevant. By addressing both technical threats and communication failures, SC-EMS strengthens resilience, supports transparency, and enhances stakeholder confidence in EMS-generated insights. This dual approach ensures that environmental monitoring can continue to serve as a reliable foundation for sustainable policy-making.

5.0 Conclusion

This paper has examined the dual challenges of cybersecurity and effective data communication in Environmental Monitoring Systems (EMS). Through a systematic review of existing literature and case studies, we developed the Secure-Communication EMS (SC-EMS) framework (Figure 1), which integrates cryptographic protection, provenance and traceability, privacy-preserving aggregation, and user-centered visualization strategies. The framework was conceptually evaluated against

documented threats and communication challenges in EMS, demonstrating its capacity to improve resilience, transparency, and trustworthiness.

The key contribution of this study lies in highlighting that cybersecurity and data presentation are not separate concerns but interconnected dimensions of EMS integrity. Strengthening one without the other risks undermining system reliability. By embedding security mechanisms alongside adaptive visualization, SC-EMS ensures that environmental data is not only protected from adversarial manipulation but also effectively communicated to diverse stakeholders, from scientists to policymakers and community members.

However, the study is not without limitations. The SC-EMS framework has been evaluated conceptually rather than through real-world deployment or simulation. As such, its practical performance against large-scale attacks, real-time data loads, and diverse user contexts remains untested. Furthermore, while blockchain and privacy-preserving methods are promising, they may introduce computational and scalability challenges in resource-constrained EMS deployments.

Future research should therefore focus on:

1. **Prototype implementation** of the SC-EMS framework in real-world monitoring projects such as air quality or flood prediction systems.
2. **Empirical evaluation** of performance, including latency, energy consumption, and resilience to evolving cyber threats.
3. **User studies** to test the effectiveness of adaptive visualization strategies in improving comprehension and decision-making among different audiences.
4. **Policy and governance frameworks** to ensure ethical use, compliance with data protection standards, and equitable access to environmental insights.

In conclusion, safeguarding Environmental Monitoring Systems requires a holistic approach that merges cybersecurity with effective data communication. The SC-EMS framework presented in this study provides a step toward this integration, offering a pathway for designing more resilient, transparent, and user-friendly EMS that can support sustainable environmental governance in an era of increasing digital threats.

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Comprehensive Review of Biometric Palmprint Features For Enhanced Biometric Identification

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Abstract

PalmPrint recognition is a physiological biometric identification and verification method that utilizes the unique characteristics of the human palm. Compared to other biometric modalities, such as fingerprints, facial features, iris patterns, gait analysis, DNA, or body odor, palmprints provide a richer combination of principal lines, minutiae points, ridge flows, and texture patterns. These features remain consistent throughout an individual's lifetime, making palmprints a reliable and secure biometric trait. The present study examines the potential of palmprint biometrics in enhancing security and personal identification across diverse applications, including forensic investigations, access control, border management, and mobile device authentication. Palmprints offer distinct advantages over other biometric traits due to their non-intrusive nature, ease of acquisition, Fast Matching Speed, high Verification Accuracy and relative resistance to forgery. Nevertheless, challenges persist in the recognition process, particularly during feature extraction. Variations in skin texture, illumination, pressure, environmental conditions, and physical factors such as dryness or injuries can significantly impact accuracy. To address these limitations, this research provides a comprehensive analysis of palmprint features aimed at improving the reliability, robustness, and efficiency of palmprint-based biometric systems. The study includes a review of existing literature, an exploration of various feature extraction techniques, and an evaluation of the significance of these features in personal identification. Additionally, the role of advanced imaging technologies, machine learning algorithms, and hybrid feature extraction methods is emphasized as essential for overcoming current challenges.

Overall, this research contributes to the development of more secure, scalable, and effective biometric authentication systems.

Keyword: *Analysis,Biometric System, Palm Print Features, Personal Identification*

1. Introduction

PalmPrint recognition is a physiological biometric system used to identify and verify individuals based on the unique characteristics of their palms (Rebin, 2024). PalmPrint is located between the wrist and fingers, the palm offers several advantages over other biometric traits, incorporating physiological, behavioral, and biological features (Salam & Taha, 2022). The study of palmprint traits has gained attention in forensic applications, security systems, and personal identification due to their reliability and uniqueness (Chakraborty & Bhaduri, 2020).

PalmPrint is a biometric system that has gained significant interest because of the distinctiveness and richness of palm-print features, making them a dependable option for identification and authentication (Salam et, al., 2022) However, based on the review of related work, a gap remains in the analysis of the various features that can be extracted from palmprints, despite their potential. A deeper understanding of these features and their significance in personal identification could substantially enhance the accuracy and robustness of palm-print-based systems (Nadia, Amir, & Abdelhafid, 2024).

Practical implementation of palmprint biometrics is, however, constrained by several challenges, which including inconsistencies in feature extraction due to variations in skin texture, environmental factors, and physical conditions such as dryness or injuries (Anup, 2025).This highlights the need for a detailed exploration of palm-print features to develop advanced, scalable, and robust methodologies that can address these limitations and improve the performance of palmprint recognition systems. The aim of this Paper is to conduct an analysis of palmprint features to enhance the reliability and efficiency of palmprint-based biometric systems which can be achieved by reviewing the existing literature on palmprint traits; analysing the various features that can be extracted from palmprints; and to assess the significance of these features in personal identification.

2. Literature Review

This section covers palmprint recognition, its uniqueness, advantages, types of palmprints, and a review of related work.

2.1 PalmPrint recognition

PalmPrint recognition is a biometric technology that identifies individuals by analysing the unique patterns of lines, ridges, and creases on their palms. These features are captured using specialized devices such as palm scanners or imaging sensors. Collected palm prints are then processed and matched against a database to verify or identify a person's identity (Gonzalez, Hu, & Chen, 2020). This

technology enables accurate and secure verification by comparing palm patterns in real-time. It is widely used in applications such as access control, attendance tracking, secure financial transactions, and even criminal investigations in law enforcement (Gonzalez et al., 2020)..

2.2 PalmPrints Uniqueness

Palmprints are highly unique, much like fingerprints. The intricate patterns of lines, ridges, and creases on the palm are distinctive to each individual, even among identical twins (Elgamily & Mohamed, 2020). The likelihood of two people having identical palm prints is exceedingly rare, making this biometric modality a reliable choice for identification and authentication (Zhao, Zhang, & Lin, 2019). Compared to iris recognition and Finger print (Kapoor, 2025), palm prints offer an advantage in terms of user acceptability, as the process of capturing palmprints is often perceived as less intrusive (Inubiwon, Bukola, & Adeiza, 2023).

Figure 1a: Palmprint feature Palm (Adapted from Sathish et al., 2021).
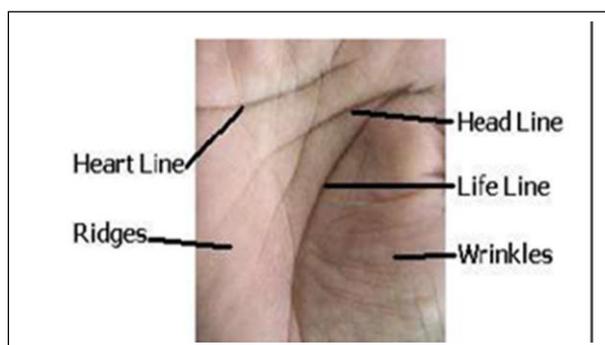
Figure 1b: Location of Principal Lines on the

2.3 Advantages of PalmPrints

Palmprint recognition offers several benefits that make it particularly effective for practical applications:

i. **Resilience to External Factors**
    Unlike fingerprints or iris recognition, palmprints are less affected by external factors such as cuts, scars, or dirt, ensuring more consistent results even in less-than-ideal conditions.

ii. **Non-Invasive and Hygienic**
    Palmprint recognition is contactless or requires minimal contact, making it more hygienic and user-friendly compared to fingerprints or iris scans, which often involve direct physical interaction.

iii. **Larger Surface Area**
    The palm provides a broader area for capturing unique features, resulting in higher accuracy and

more distinctive patterns for verification and identification.

iv. **Uniqueness and Accuracy**
     Each person's palm print is uniquely identifiable, ensuring a high level of precision in authentication and reducing the risk of duplication.

v.   **Stability Over Time**
     Palmprints remain relatively consistent throughout an individual's life, making them suitable for long-term use in biometric systems (Dhiman, Gupta, & Sharma, 2021).

vi. **Versatility Across Demographics**
     Palmprint recognition works effectively across all age groups, genders, and ethnicities, ensuring its applicability to diverse populations(Salam & Taha, 2022).

2.4 Types of Palmprints

Palmprints are classified into three categories based on their characteristics and how they are captured (Khan, Ali & Shafique, 2022). Each type is explain detailed below:

Latent Palm print

Latent palmprints are invisible or difficult to detect with the naked eye. These prints are formed when friction ridges on the skin leave impressions on a surface, often unintentionally. They can be revealed using various techniques such as electronic, physical, or chemical processing. Substances like sweat from the accrue glands, blood, oil, paint, or ink can also contribute to creating latent palm-prints. It can be used to identify deficiencies, deformities, overlaps, or other unique characteristics (Elbendary, Khalil, Saafan, & Moustafa, 2024).

Patent Palmprint

Patent palmprints are visible to the naked eye and occur when an external substance, such as dirt, ink, or blood, is transferred onto the palm's surface. Unlike latent prints, patent palmprints do not require additional enhancement or processing for visibility. These are often captured directly using photography or other recording methods.

Plastic Palm Print

Plastic palmprints are three-dimensional impressions left on a soft or malleable surface, such as clay, wax, or putty. These impressions preserve the texture of the palm, including the ridges and contours. Plastic palmprints are visible without enhancement and can be documented through photography or replication techniques. However, due to the specific conditions required to form such prints, they are not easily encountered at crime scenes (Li, Zhang, & Sun, 2021).

2.5 Review of related work

Adrian-Stefan, Salahuddin, and Corcoran (2020) proposed a framework for

unconstrained palmprint recognition on consumer devices. The study emphasized the advantages of palmprints over fingerprints and facial recognition. Techniques reviewed include ROI extraction (for palm area segmentation), feature extraction methods (capturing line and texture features), and matching algorithms, alongside an analysis of datasets.

Akash, Kanishk, and Deepak (2021) examined the role of deep learning in biometric recognition systems. Deep neural networks were applied to automatically extract discriminative features such as texture patterns and structural properties of palmprints, leading to robust identification, secure template storage, and enhanced reliability.

Sathish, Baskar, and Vinod (2021) investigated palmprint biometrics using line-based edge detection methods. Using the CASIA database, operators such as Prewitt, Sobel, Canny, Kirsch, and Multiscale Edge Detectors were applied to extract line features and edge patterns. The Kirsch operator achieved the highest accuracy, with 94.95% at 1% FAR and 94.85% at 2% FAR. Salam and Taha (2022) provided a review of palmprint recognition techniques over a 15-year period. The analysis considered methods for extracting line features, texture features, and geometric patterns. Comparisons were drawn between handcrafted feature extraction techniques and machine learning or deep learning approaches, which are capable of extracting hierarchical structural features automatically.

Nadia, Ami, & Abdelhafid (2023) surveyed palmprint recognition methods, focusing on feature extraction, datasets, and algorithms. Their taxonomy categorized extracted features into:

a. Line-based features (principal lines and wrinkles),

b. Texture descriptor-based features (local texture patterns),

c. Subspace learning features (dimensionality-reduced representations),

d. Local direction encoding features (orientation-based information), and

Deep learning features (hierarchically learned patterns). Twenty datasets were reviewed, and research challenges were outlined.

Kumari, Deepika, Jyoti, and Anuradha (2023) conducted a systematic review on multimodal biometrics combining palm and wrist traits. Filtering techniques for noise reduction and optimization of feature selection were analyzed. Extracted features included texture details from palmprints and vein/skin fold structures from the wrist. Findings indicated that integrating palm and wrist features enhances system

performance. Priti, Agar, Lalitkumar, Kishor, & Aparna (2023) proposed a CNN-based soft computing approach for palm biometric feature extraction. The system extracted deep features from palm vein images, with emphasis on texture and vascular structures, which improved reliability. Sumalatha, Krishma, Sumalatha, Krishma, Prabhu, & Nayak. (2024) reviewed unimodal and multimodal fingerprint biometrics. Though not palmprint-specific, the review discussed extraction of minutiae features (ridge endings and bifurcations), texture features, and fused multimodal features. These enhance robustness, protect templates, and mitigate challenges such as noisy data and spoof attacks.

Tarek, Abeer, Mahmoud, & Hossam (2024) proposed a palmprint recognition model based on a deep residual network (ResNet). Extracted features included deep hierarchical attributes such as texture, line, and structural patterns from raw palmprint images. Experiments conducted on CASIA, IIT Delhi Touchless, and SMPD datasets demonstrated an accuracy of 99.75%.

Chengrui, Ziyuan, Wei, Lu, Bob, and Andrew (2025) presented a survey on deep learning in palmprint recognition. The study highlighted how deep networks extract rich features including global texture representations, local ridge/line patterns, and orientation-based features. Recent advancements in deep learning-powered palmprint feature extraction were reviewed, addressing gaps left by earlier surveys that narrowly focused on specific tasks

3. Methodology

This section outlines the procedural steps involved in palm print recognition systems.
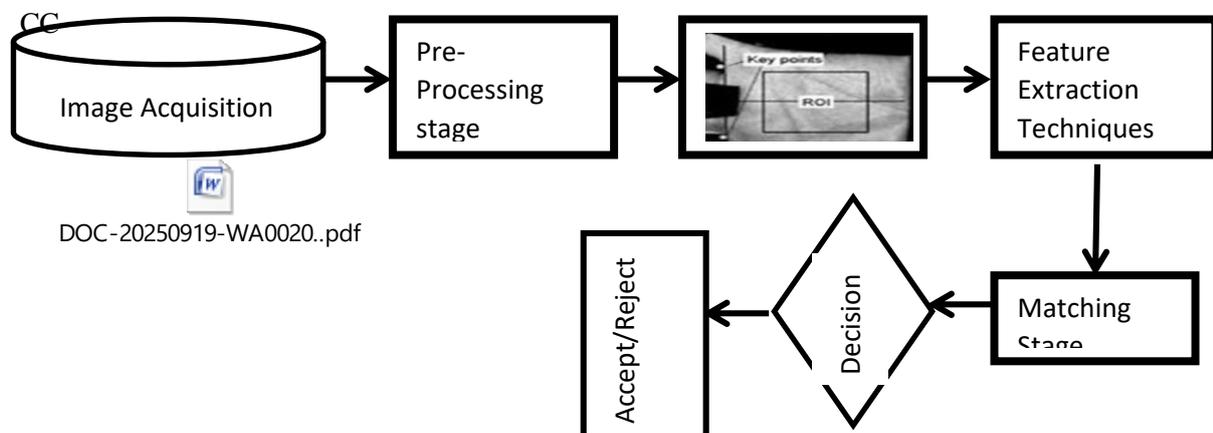
Figure 2: Research Framework for the Palm Print Recognition System.

Step 1: Image Acquisition

Image acquisition was the first step in the palmprint recognition system. Advances in imaging technology, such as infrared and high-resolution cameras, enabled the capture of detailed palmprint images, even under challenging conditions. During this phase, it was essential to ensure optimal lighting and positioning to minimize variability in the images captured. The quality of the acquired images significantly influenced the subsequent processing steps, making the use of state-of-the-art imaging techniques crucial. Different devices were used to capture palmprints, such as CCDs, cameras, and scanners.

Step 2: Pre-Processing

Pre-processing refined palmprint images through noise reduction, contrast enhancement, normalization, distortion removal, alignment, and ROI cropping, ensuring clarity for feature extraction.

Step 3: Feature Extraction

Feature extraction was a critical step in palmprint recognition, transforming raw palmprint images into a set of distinctive features suitable for identification. Various techniques were developed for feature extraction, including texture analysis, geometric feature extraction, and minutiae-based approaches. Texture analysis methods, such as Local Binary Patterns (LBP) and Gabor filters, were widely used for their ability to capture intricate texture information from palmprint images. Geometric feature extraction emphasized the overall shape and structure of the palmprint, while minutiae-based approaches focused on identifying specific points of interest, such as ridge endings and bifurcations. The choice of feature extraction technique significantly impacted the overall performance of the recognition system.

Despite advancements in palmprint recognition technology, several challenges remained. Variability in palmprint images resulted from factors such as skin condition, angle of capture, and the pressure applied during acquisition, leading to inconsistencies in recognition performance. Additionally, as biometric systems became increasingly integrated into daily life, concerns regarding privacy and

security arose. The collection and storage of biometric data raised ethical questions about consent, data protection, and the potential for misuse. Addressing these concerns was essential for building public trust in biometric technologies and ensuring their successful implementation.

3.1 Techniques for Feature Extraction

Several techniques were used to extract features from palmprint images, commonly applied in biometric systems for identification and authentication (Zhang, Wang, & Li, 2021). These included:

a. Texture-Based Feature Extraction: Palmprint images contained rich texture information captured through methods such as Gabor filters, Laws mask texture, Discrete Fourier Transform (DFT), Discrete Cosine Transform (DCT), wavelets, Local Binary Patterns (LBP), and 2D Linear Programming Projection (2DLPP).

b. Statistical-Based Feature Extraction: Features were extracted using statistical measures such as mean, variance, standard deviation, Zernike moments, Hu invariant moments, L1-norm energy, and variance. Approaches included both local (region-based) and global methods.

c. Subspace-Based Feature Extraction: Subspace methods reduced high-dimensional input spaces into lower-dimensional subspaces. Techniques included Principal Component Analysis (PCA), Linear Discriminant Analysis (LDA), Concurrent Subspaces Analysis (CSA), and Multiline Discriminant Analysis (MDA).

d. Line-Based Feature Extraction: This approach focused on significant palm lines and ridges. Methods included line matching, line detection, crease detection, morphological operations, and edge detection (Canny, Prewitt). Each of these methods encoded palmprint information into feature vectors that were later applied in machine learning and artificial models for classification or identification tasks.

Step 4: Matching Stage

The final stage of palmprint recognition was matching, where the extracted features were compared against stored templates in a database to identify or verify individuals. Various matching algorithms were proposed, ranging

from simple distance-based methods to advanced machine learning techniques. The selection of an algorithm influenced the system's speed and accuracy, especially in real-time applications. Extracted features were used to generate a template—a mathematical representation of the palmprint's unique characteristics. This template was stored in a database for future comparison. For verification or identification, the captured palmprint was compared with stored templates, and the system analyzed similarities to determine a match or non-match.

4. Results and Discussion

Palmprint features play a crucial role in personal identification due to their uniqueness, stability, and complexity. Distinct characteristics such as principal lines, ridges, and minutiae points are unique to each individual, even among twins. These features remain stable throughout life, are hard to forge, and can be captured non-invasively. Palmprint recognition systems leverage these traits for precise identification and authentication, especially in security-critical applications like access control, forensic analysis, and mobile device authentication.

Palmprint features were analyzed through various image processing and pattern recognition techniques. Guidelines on analyzing some key palmprint features included:

a. **Lines and creases:** These features were typically extracted through ridge extraction algorithms that identified the ridges and valleys of the palmprint. Techniques such as Gabor filters or directional filters were used. Parameters such as ridge density, ridge thickness, and ridge continuity were measured for comparison and matching. Principal line features were the major ridges and lines on the palm used for identification (Sathish et al., 2021).

b. **Minutiae points:** Minutiae points were local features in palmprints, such as ridge endings, bifurcations, and crossovers. They were crucial for individual identification due to their uniqueness. Methods such as the Crossing Number or BSIF were used for

detection, and minutiae analysis involved extracting coordinates, direction, and type for precise matching across palmprints.

c. **Texture:** Texture features in palmprints were analyzed using methods such as Local Binary Patterns (LBP) or Gabor filters to extract textural information. Statistical properties of the texture, such as mean, standard deviation, entropy, or co-occurrence matrices, were computed. These properties helped distinguish palmprints with similar ridge patterns (Anup, 2025).

d. **Singular points:** Singular points were large-scale, global features of a palmprint. They represented the overall structure of the ridge flow pattern. Examples included the core point (the central point of a ridge pattern, often found in loops or whorls) and the delta (a triangular region where ridge lines diverged in three directions, commonly located near the base of fingers or the palm).

e. **Delta Point in Palmprint**

A delta point in palmprint recognition is a triangular region where ridge lines split and flow in three different directions. It looks like the Greek letter "Δ" (delta), hence the name. It is usually located at the base of fingers (especially the index and little fingers) or near the base of the palm. Delta points are considered singular points because they describe the global structure of ridge flow. They are important in biometric systems because their position and orientation provide unique markers that help in palmprint classification and matching.

f. Dot (Dotun) in Palmprint

In palmprint terminology, a dot (sometimes referred to as "dotun" in descriptive texts) is a very short ridge that appears as a tiny dot-like structure. Dots are considered minutiae features, just like ridge endings and bifurcations. They are small, isolated ridges that do not connect to others. Their location,

frequency, and pattern contribute to the uniqueness of a palmprint.

g. Datum Point in Palmprint

A datum point in palmprint recognition refers to a reference point on the palm used for alignment, normalization, and region of interest (ROI) extraction. Palmprints are large and complex, researchers need a consistent way to "anchor" the image so that the same region of the palm is always analyzed. Datum points serve as those anchors.

5. Recommendations and Conclusion

Palmprint recognition is a reliable biometric system that leverages unique palm features for identification and verification. Studies reviewed highlight methods such as line, texture, and deep learning-based feature extraction, with multimodal systems improving performance. Despite progress, gaps remain in exploring singular features like minutiae, delta, and dot patterns. This study contributes by consolidating research, identifying underexplored features, and emphasizing multimodal approaches.

Future work should focus on advanced feature extraction, fusion strategies, and robust deep learning models for real-world applications.

From the analysis of previous studies indicates that advancements in feature extraction, combined with modern machine learning and deep learning models, have significantly enhanced recognition accuracy and robustness. However, a notable gap persists in the exploration of underutilized palm features such as singular points and minutiae patterns. Addressing these gaps can lead to stronger, more reliable systems capable of withstanding real-world challenges such as noisy data, spoofing attempts, and environmental variations.

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An efficient hybrid conjugate gradient method for non-linear minimization problems.

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Abstract

Conjugate gradient methods form an important class of iterative algorithms for solving unconstrained optimization problems, with numerous classical variants proposed by different authors. While traditional approaches such as the Hager-Zhan and Hestenes-Stiefel methods have been widely applied, they are not without limitations, particularly in terms of convergence speed and robustness on certain classes of problems. To address these challenges, this study develops a new hybrid conjugate gradient algorithm, denoted as β_k^{HYB}, which is constructed as a convex combination of existing classical methods. The choice of the parameter ensures that the generated search direction satisfies Newton's direction, thereby maintaining strong theoretical properties. Under the Strong Wolfe line search scheme, the proposed hybrid algorithm is proven to be globally convergent while also satisfying the descent condition property. Numerical computations demonstrate that consistently outperforms its classical counterparts in many test cases, especially where traditional algorithms show slow convergence or outright failure. However, results also reveal that there remain isolated instances where a classical method performs better, indicating that the hybrid is not universally superior. Despite this, the findings confirm that hybridization leads to meaningful improvements in efficiency and robustness, particularly for large-scale optimization problems.

Keywords: *Conjugate gradient method, Newtons search direction, convex-combination.*

$$(3)$$

1.   Introduction

The Conjugate Gradient Method (CGM) is a powerful iterative algorithm primarily used for solving systems of linear equations, particularly those that are large, sparse, and symmetric positive definite (Fletcher and Reeves1964) . It is also widely applied in optimization problems, especially for minimizing quadratic functions. The method is particularly advantageous in scenarios where direct methods, such as Gaussian elimination, become computationally expensive due to the size of the matrix involved.

The Conjugate Gradient Method provides a means to find solutions with significantly reduced computational effort, especially when the matrix involved is sparse. Consider the nonlinear unconstrained minimization problem

$$Min\ f(x) : x \in \mathbb{R}^n$$

$$(1)$$

where $f(x): \mathbb{R}^n \to \mathbb{R}$ is a continuously differentiable function and $\mathbb{R}$ denotes an $n-$dimensional Euclidean space.

Equation 1 can be solved using different approaches $(direct\ or\ iterative\ methods)$, this research work, focuses on conjugate gradient method due to it's strong convergence properties and low memory requirement. The Conjugate gradient method iteratively solves (1) by starting from an initial guess $x_0 \in \mathbb{R}$ and generates a sequence of points $x \in \mathbb{R}^n$ using the recursive formula

$$x_{k+1} = x_k + \alpha_k d_k$$

$$(2)$$

where α_k is the step size and $d_k \in \mathbb{R}^n$ is the search direction defined as follows

$$d_{k+1} = \begin{cases} -g_{k+1} & k = 1 \\ -g_{k+1} + \beta_k d_k & k \geq 2 \end{cases}$$

where β_k is known as conjugate gradient parameter and $g_x = \nabla f(x)$ is the gradient of $f(x)$, and the step lenght α_k is calculated using the line search rule given below,

$$f(x_k) + \alpha_k d_k - f(x_k) \leq \delta \alpha_k g^T d_k \qquad (4)$$

$$g_{k+1}^T d_k \geq \sigma g^T d_k$$

$$f(x_k) + \alpha_k d_k - f(x_k) \leq \delta \alpha_k g_k^T d_k \qquad (6)$$

$$|g_{k+1}^T d_k| \leq \sigma g_k d_k$$

Equations (4) and (5) is called the Standard Wolfe and (6) and (7) is called the Strong Wolfe condition,

The choice of parameter β_k lead to different CGM. some of the popular methods are:

$$\beta_k^{FR} = \frac{\|g_{k+1}\|^2}{\|g_k\|^2} \qquad \text{(Fletcher and Reeves1964)}$$

$$(8)$$

$$\beta_k^{DY} = \frac{\|g_{k+1}\|^2}{d_k^T y_k} \qquad \text{(Dia and Youan2000)}$$

$$(9)$$

$$\beta_k^{DX} = \frac{\|g_{k+1}\|^2}{-g_k^T d_k} \qquad \text{(Dixon1975)}$$

$$(10)$$

$$\beta_k^{PRP} = \frac{g_{k+1}^T y_k}{\|g_k\|^2} \qquad \text{(Polyak Reber 1969)}$$

$$(11)$$

$$\beta_k^{HS} = \frac{g_{k+1}^T y_k}{y_k^T d_k} \qquad \text{(Hestenes and steifil 1952)}$$

$$(12)$$

$$\beta_k^{HZ} = \frac{1}{d_k^T y_K}\left(y_k^T - 2d_{k^T}\frac{\|y_k\|^2}{d_k^T y_k}\right)g_{k+1} \qquad \text{(Hager and Zhan2006)} \qquad (13)$$

$$\beta_k^{BAN} = \frac{g_{k+1}^T y_k}{g_k^T y_k} \qquad \text{(Bamigbola, Ali, Nweze 2010)}$$

(14)

Some of these CG methods with $\|g_k\|^2$ in the numerator are known to have strong convergence properties but they have tendencies to strays while those with $g_{k+1}^T y_k$ in the numerator may not generally converge but have good computational capabilities.

These classical Conjugate Gradient algorithms above has various drawbacks ranging from convergence to computational strength hence the need for an improved algorithm, (Andrei, N., et al. 2020). To overcome these challenges, hybrid methods were developed by integrating the advantages of various conjugate gradient methods, our proposed approach aims to overcome the limitations of traditional optimization algorithms while leveraging their respective strengths.

In this paper, we develop some hybrid methods, prove the descent conditions and global convergence of the derived algorithms. The hybrid method is due to the convex combination of Hestenes-Stiefiel method and Hager-Zhan method.

2.   Methodology

2.1   Hybrid Conjugate Gradient Method formulation

This research propose an efficient hybrid scheme due to the convex combination of the classical methods developed by Hager-Zhan β_k^{ZH} (13) and Hestines− Steifil   (12)β_k^{HS}. as follows:

From $(3), (12)$ and (13) we have

$$d_{k+1} = -g_{k+1} + \beta_k^{NEW} d_k$$

$$\text{where}\quad \beta_k^{NEW} = \theta_k \beta_k^{ZH} + (1-\theta_k)\beta_k^{HS}$$

(15)

we choose θ_k such that the direction d_{k+1} satisfies the newtons direction i.e.

$$-\nabla^2 f(x_{k+1})^{-1} g_{k+1} = -g_{k+1} + \beta_k^{NEW} d_k$$

(16)

multiplying (16) by $S_k^T \nabla^2 f(x_{k+1})$ from the left we have

$$-S_k^T g_{k+1} = -S_k^T \nabla^2 f(x_{k+1}) g_{k+1} + \beta_k^{NEW} d_k \quad (17)$$

using the secant condition $S_k^T \nabla^2 f(x_{k+1}) = y_k$ (18)

$$\to -S_k^T g_{k+1} = -y_k^T g_{k+1} + (1 - \theta_k)\beta_k^{HS} y_k^T d_k + \theta_k \beta_k^{HZ} y_k^T d_k$$

by expansion we have:

$$\to -S_k^T g_{k+1} = -y_k^T g_{k+1} + \beta_k^{HS} y_k^T d_k + \theta_k \beta_k^{HS} y_k^T d_k + \theta k \beta_k^{HZ} y_k^T d_k$$

which gives:

$$-S_k^T g_{k+1} + y_k^T g_{k+1} - \beta_k^{HS} = \theta_k (\beta_k^{HZ} - \beta_k^{HS})(y_k^T d_k)$$

$$\to \theta_k = \frac{-S_k^T g_{k+1} + y_k^T g_{k+1} - g_{k+1}^T y_k}{(\beta_k^{HZ} - \beta_k^{HS})(y_k^T d_k)}$$

$$\to \theta_k = \frac{-S_k^T g_{k+1}}{(\beta_k^{HZ} - \beta_k^{HS})(y_k^T d_k)}$$

using (1.5) and (1.6) we have,

$$\to \theta_k = \frac{-S_k^T g_{k+1}}{\left(\frac{1}{d_k^T y_k}\left(y_k^T - 2d_{k^T}\frac{\|y_k\|^2}{d_k^T y_k}\right)g_{k+1} - \frac{g_{k+1}^T y_k}{g_k^T y_k}\right)(y_k^T d_k)}$$

(19)

After some simplification (19) becomes

$$\theta_k = \frac{-S_k^T g_{k+1}}{y_k^T - 2d_{k^T} \frac{\|y_k\|^2}{d_k^T y_k} g_{k+1}} \qquad (20)$$

2.2   Algorithm

Step 1

Initialization: set $x_n \in \mathbb{R}$ and compute $f(x_0) = g_0$ and $\alpha_0 = \frac{1}{\|g_0\|}$ and $k = 1$

Step 2

Test for continuity of the algorithm: if $\|g_k\| \leq 10^{-10}$, then stop

Step 3

Line search : Compute α_k satisfying the line search criterion (19) and (20) and update the variables
$x_{k+1} = x_k + \alpha_k d_k$ and compute $f(x_{k+1})$, and $g(x_{k+1}), S_k = x_{k+1} - x_k$ and $y_k = g_{k+1} - g_k$

Step 4

Parameter computation

If the denominator of (20) is Zero then set $\theta = 0$ otherwise compute θ as given in (20)

Step 5

Conjugate gradient parameter computation, compute β_k^{New} as given in (17)

Step 6

Computation of direction

Compute $d_{k+1} = -g_{k+1} + \beta_k^{New} S_k$

Step 7

Set $k = k + 1$ and go to step 2.

2.3   Convergence Analysis

1.   Sufficient Descent Condition

For and algorithm to be efficient, it is necessary that it is convergent and hence satisfy the sufficient descent condition. Here we prove the that the proposed method is a descent method.

Theorem 1

Given the Conjugate gradient method defined by (2) and (4) then

$$g_{k+1}^T d_k \leq -C\|g_{k+1}\|^2 \qquad C > 0 \qquad (21)$$

We prove (21) by induction

Let $k = 0, \Rightarrow g_k^T d_k \leq -c\|g_k\|^2$

Assume it is true for k, i.e.

$$g_k^T d_k \leq -c\|g_k\|^2$$

(22)

To prove that it is true for $k + 1$

$$d_k = -g_{k+1} + (\theta \beta_k^{HZ} + (1 - \theta)\beta_k^{HS})d_k$$

(23)
by expansion we have

$$d_k = \theta(-g_{k+1} + \beta_k^{HZ} d_k) + (1 - \theta)(-g_{k+1} + \beta_k^{HS} d_k) \quad (24)$$

multiplying both sides of (24) by g_{k+1} from the left gives

$$g_{k+1}^T d_k = \theta g_{k+1}^T d_k^{HZ} + (1 - \theta)g_{k+1}^T d_k^{HS} \quad (25)$$

we consider the solution of (25) under 3 cases

$$\theta = 0, \quad \theta = 1 \quad , \text{ and } \quad 0 \leq \theta \leq 1$$

If $\theta = 1$

Then (25) reduces to $g_{k+1}^T d_k = \theta g_{k+1} d_k^{HZ}$, this result was proven to satisfy the sufficient descent condition, $\exists \, C = \frac{7}{8}\|g_{k+1}\|^2$, Hager and Zhan (2006)

$$\Rightarrow g_{k+1}^T d_k^{HZ} = \frac{7}{8}\|g_{k+1}\|^2$$

(26)
Also is, if $\theta = 0$, then

$$g_{k+1}^T d_k = g_{k+1}^T d_k^{HS} \quad (27)$$

and from literature, it can be seen that

$$g_{k+1}^T d_T = -\left(\frac{1-2.2\sigma}{1-\sigma}\right) \quad (28)$$

$$\Rightarrow g_{k+1}^T d_k = -C\|g_{k+1}\|^2 \text{ where } C = \frac{1-2.2\sigma}{1-\sigma}$$

Hence for $0 \le \theta \le 1$ we have that

$$g_{k+1}^T d_k^{NEW} = \frac{7}{8}\theta\|g_{k+1}\|^2 + (1 - \theta)\left(-\left(\frac{1-2.2\sigma}{1-\sigma}\right)\|g_{k+1}\|^2\right) \quad (29)$$

$$g_{k+1}^T d_k^{NEW} = -C\|g_{k+1}\|^2 \text{ where C is a constant}$$
(30)

2.   Convergence Analysis

To illustrate the global convergence of the proposed method we'll propose and prove a theorem based on the following assumptions.

Assumption 1

The level set $S = x \in \mathbb{R}: f(x) \le f(x_0)$ is bounded below. That is there exists a positive constant B such that

$$\|x\| \le B \quad \forall \quad x \in S$$

Assumption 2

In the neighborhood N of S, the objective function is continuously differentiable and its gradient g(x) is Lipschitz continuous on N that is, $\exists$ a constant $L \ge 0$ such that:

$$\|f(x) - f(y)\| \le L\|x - y\|, \forall x, y \in \mathbb{N}$$

(31)

Under assumption (1) and (2) on f there exists a constant r such that

$$\|g_x\| \le r, \forall x \in S$$

Theorem 2

Let assumption (1) and (2) hold, consider the method (3) and (4) where d_k is a descent direction and α_k satisfies the strong Wolfe's condition, if

$$\sum_{k=1} \frac{1}{\|d_k\|^2} = \infty , \text{ then } lim_{k\to\infty}\|g_x\| = 0$$

(32)
A CGM algorithm is globally convergent if $\|g_x\| = 0$ for some K as (32) holds.

Proof

We proof the above theorem by contradiction, i.e. suppose that $g_k \neq 0 \ \forall$ k. Then we have to show that $\exists$ a constant r $\ge$ 0, such that

$$\|g_x\| \ge r, \forall k.$$

Let D be the diameter of the level set S, then from

$$\beta_k^{HYB} = \theta\beta_k^{HZ} + (1 - \theta)\beta_k^{HS} \text{ we get}$$

$$|\beta_k^{HYB}| \le |\beta_k^{HZ}| + |\beta_k^{HS}|$$

Using (13) and (14)

$$|\beta_k^{HYB}| \le \left|\frac{1}{d_k^T y_k}\left(y_k^T - 2d_k^T \frac{\|y_x\|^2}{d_k^T y_k}\right)^T g_{k+1}\right| + \left|\frac{g_{k+1}^T y_k}{d_k^T y_k}\right|$$

(33)
It is known that

$$y_k^T d_k = g_{k+1}^T d_k - g_k^T d_k$$

$$y_k^T d_k \ge (\sigma - 1)g_k^T$$
$$= -(1 - \tau)dk - g_k^T dk$$

$$\frac{1}{y_k^T d_k} \le \frac{1}{-(1 - \tau)g_k^T d_k}$$

from the conjugacy condition

$-g_k^T d_k \geq C\|g_k\|^2$

which gives $\frac{1}{g_k^T d_k} \geq \frac{1}{-C\|g_k\|^2}$

(34)

From the statement of the contradiction

$$\|g_k\| \geq r$$

Hence (34) becomes

$$-\frac{1}{g_k^T d_k} \leq \frac{1}{Cr^2}$$

Also from (33)

$$-\frac{1}{y_k^T d_k} \leq \frac{1}{-(1-\sigma)g_k^T d_k}$$
$$\leq \frac{1}{(1-\sigma)cr^2}$$

From the Liptchiz condition

$$|f(x) - f(y)| \leq L|x - y|$$
$$\Rightarrow |g(x+1) - g(x)| \leq L|x_{x+1} - x_x|$$
$$\Rightarrow |y_x| \leq LD$$

Hence $|g_{k+1}^T y_k| \leq |g_{k+1}||y_k|$

$$\therefore |g_{k+1}^T d_k| \leq rLD$$

Now (33) simplifies into

$$\beta_k^{HYB}| \leq |\frac{1}{(1-\sigma)Cr^2|}\left(rLD\right.$$
$$\left. - 2Cr^2 \frac{(LD)^2}{(1-\sigma)Cr^2|}\right)$$
$$+ |\frac{rLD}{(1-\sigma)Cr^2|} = M$$
$$d_{k+1} = -g_{k+1} + \beta_k^{HYB} d_k \leq -|g_{k+1}| +$$
$$|\beta_k^{NEW}||d_k|$$
(35)

$$d_{k+1} \leq r + MD$$

$$\Rightarrow \frac{1}{\|d_{k+1}\|} \geq \frac{1}{r+MD} \text{ and using}$$

(Zoutendijk, G. 1970). Condition we have

$$\Rightarrow \sum_{k \geq 1} \frac{1}{\|d_{k+1}\|} = \infty$$

Applying Theorem 2, we conclude that $\lim_{k \to \infty} inf\|g_k\| = 0$. Hence, the proof.

4.   Results and Discussions

Numerical Computation

In this section, we turn to a numerical investigation of our proposed method, comparing its performance with several well-known existing algorithms (for instance, variants of the non-linear conjugate gradient family). We assess efficiency using standard benchmark (test) functions with fixed and commonly used initial points x_0.

A primary indicator of algorithmic efficiency is the total number of function evaluations needed to reach the true solution x∗, under a given stopping criterion (e.g. gradient norm below a tolerance). Other indicators include the number of iterations, CPU/time use, and possibly the behaviour of the norm of the gradient across iterations (convergence profile).

Below we list some classical test functions and describe how the algorithm performs on these, showing convergence rates, number of function evaluations, gradient norms, and comparing results side by side with CG-DESCENT (Hager–Zhang) and HS. Performance profiles based on (Dolan and More 2002) is equally shown graphically in Figures 1.

Table 1 and Table 2 gives a comparison of our second hybrid β_k^{HYB} with those of its constituent classical algorithm; β_k^{HZ} and β_k^{HS}. It was discovered that th hybrid method performs better than the classical methods using the various metric of measurement.

Table 1: *Performance of the Hybrid Method (Extended Rosenbrock Function).*

N	Method	iter	CUP Time	F(x)	Norm
100	HZ	244	0.795	2.132931e-13	9.84e-07
	HS	70	0.204	9.385224e-14	6.29e-07
	OJO	30	0.094	1.199181e-13	8.18e-07
1000	HZ	218	0.623	9.401723e-16	8.12e-07
	HS	74	0.231	1.365555e-13	7.58e-07
	OJO	35	0.119	7.647901e-15	7.70e-07
5000	HZ	160	0.756	9.572674e-15	6.10e-07
	HS	78	0.560	9.934088e-14	6.47e-07
	OJO	39	0.211	8.719505e-14	7.05e-07
10000	HZ	193	1.576	1.781397e-15	7.52e-07
	HS	78	0.550	1.986800e-13	9.15e-07
	OJO	48	0.495	1.732131e-14	5.95e-07

Table 2: *Performance of the Hybrid Method (Extended MCCORMCK Function).*

N	Method	Iter	CUP Time	F(x)	Norm
100	HZ	40	0.142	-9.566115e+01	8.70e-07
	HS	99	0.267	-9.566115e+01	9.87e-07
	HYB	52	0.157	2.674250e+03	8.83e-07
1000	HZ	89	0.261	-9.566115e+02	1.40e-13
	HS	154	0.412	-9.566115e+02	1.52e-08
	HYB	56	0.197	2.674250e+04	7.90e-07
5000	HZ	49	0.272	-4.783057e+03	3.5e-08
	HS	1676	7.315	-4.783057e+03	2.94e-07
	HYB	162	0.727	1.837125e+05	7.66e-07
10000	HZ	46	0.333	-9.566115e+03	2.59e-07
	HS	130	0.728	-9.566115e+03	5.15e-08
	HYB	69	0.166	-7.239797e+03	2.84e-07
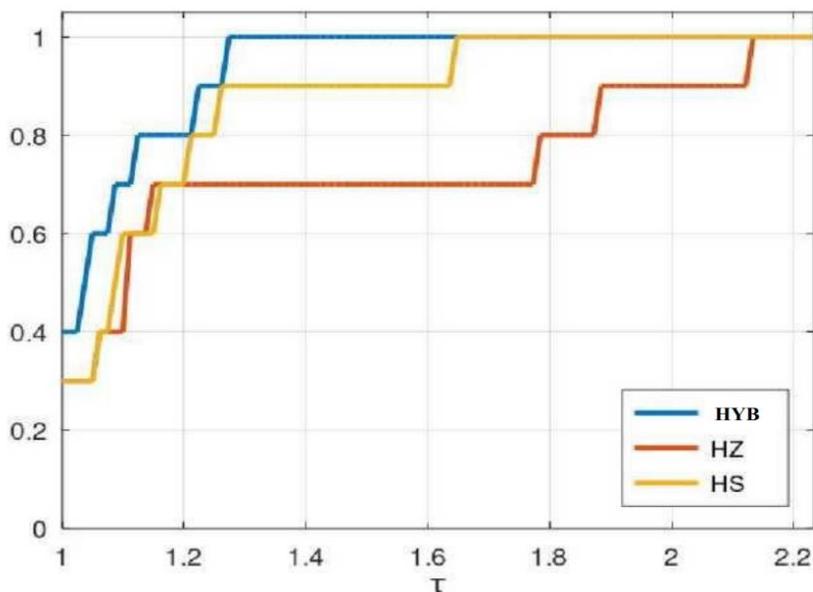
Figure 1: Performance Profile of the methods.

5.   Conclusion

In this study, we introduced a new hybrid conjugate gradient algorithm, β_k^{HYB} constructed as a convex combination of several classical conjugate gradient methods. Our tests show that β_k^{HYB} often outperforms the classical methods, especially on functions where the traditional approaches struggled. This demonstrates that hybridization is not just a theoretical curiosity—it can lead to real improvements in efficiency and robustness. However, it's important to note that there was at least one test problem in which a classical method performed better than our hybrid, signaling that β_k^{HYB} is not a universal solution but rather a promising step forward.

Given these results, we recommend that practitioners consider using β_k^{HYB} in settings where classical methods exhibit slow convergence or fail outright, particularly in large-scale optimization problems. It would also be beneficial to perform extensive benchmarking with diverse types of functions to fully map out when the hybrid method has the greatest advantage. Also, exploring more adaptive ways to set the convex-combination parameter could help in tailoring the algorithm to different problem structures, potentially preventing cases where classical methods still do better.

For future work, we suggest investigating dynamic or data-driven rules for choosing the weights in the convex combination so the algorithm can adjust itself based on how the optimization is proceeding. Relaxing some of the strong assumptions—such as the exact form of line search conditions—might expand the applicability of the method. Extending the approach to constrained optimization or to problems with inexact or noisy gradient information would also be valuable, as would carrying out more theoretical work to derive explicit convergence rates under different assumptions. Over time, these directions could help make hybrid conjugate gradient methods more reliable and broadly applicable.

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Entreprenuerial Financing and Growth Of Microfinance Banks In Kogi East, Kogi State, Nigeria.

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Abstract

Financial institutions are central to a nation's economic transactions, and Microfinance Banks (MFBs) play a critical role in this regard. However, many MFBs are becoming less effective due to their limited customer base, which hinders growth. Over the years, they have faced persistent challenges that constrain their operations. This study examines the relationship between entrepreneurial financing and the growth of MFBs in Kogi East, Kogi State. A survey research design was adopted, with questionnaires administered to generate data, which were analyzed using descriptive and inferential statistics. Regression analysis was conducted with SPSS (version 26.0) to test the hypotheses. The findings reveal that entrepreneurial financing significantly enhances the growth of MFBs, serving as a catalyst for their expansion. Specifically, financing options such as crowdfunding, venture capital, and debt financing were found to contribute positively to growth. The study concludes that entrepreneurial financing has a strong and significant effect on MFB growth in Kogi East. It recommends expanding crowdfunding initiatives to increase the customer base, improving access to venture capital, and strengthening debt financing options. Furthermore, individual characteristics should be considered as potential moderators of the effects of entrepreneurial financing dimensions on MFB growth.

Keywords: Entrepreneurship Financing, Crowdfunding, Venture Capital, Debt Financing, Microfinance Banks, Growth.

1. Introduction

Growth of financial institutions is dependent on the way in which activities of such firms are carried out. Many of these institutions develop through increase in number of employees, high return on sales, increase in branches and locations as well as increase in profit level. These institutions such as microfinance banks need to understand why the practice of entrepreneurial finance is necessary. The emergence of microfinance banks had really necessitated the growth of several businesses in the global world. In today's global economy, entrepreneurial finance has emerged as a critical driver of growth, particularly as businesses face unprecedented challenges and opportunities. Entrepreneurs often find themselves at the crossroads of growth, requiring substantial financial resources to bring their groundbreaking ideas to market. However, access to adequate financing remains a weighty barrier, particularly in an atmosphere where traditional financial institutions such as microfinance banks may be reluctant to fund high-risk ventures (Robb & Robinson, 2014). The increasing complexity of global markets, coupled with the rapid pace of technological change, exacerbates these challenges, making the role of entrepreneurial finance more dynamic than ever. Adequate entrepreneurial finance provides the necessary capital and catalyzes growth by enabling businesses to scale rapidly and compete globally (Bonini &

Capizzi, 2019). The evolving nature of markets has intensified the need for growth financing strategies that are flexible and responsive to the irreplaceable needs of entrepreneurs. The connection of financial access and growth highpoints a critical hypothetical issue: how can entrepreneurial finance be optimized to support sustained growth in a constantly changing economic landscape? This question strengthens much of the modern discourse on the subject, signaling a need for more indepth exploration of the mechanisms that link entrepreneurial finance with successful growth outcomes (Bruton *et al*., 2015). Recent studies have increasingly focused on exploring the complex dynamics between entrepreneurial finance and innovation. For instance, Khattak *et al*. (2021) emphasized the crucial role of entrepreneurial finance in directly contributing to financial performance and indirectly enhancing environmental and innovative performance through corporate social responsibility. This highlights the broader impact of entrepreneurial finance beyond immediate financial outcomes. Frimanslund *et al*., (2023) explored how access to finance is vital to entrepreneurial ecosystems, providing the necessary capital to drive innovation and growth. The importance of contextual factors has also been underscored in the literature. Rossi *et al*. (2020) highlighted the opportunities created by recent disruptive trends, such as digitization and novel statistical

approaches, particularly in venture capital research. Anwar *et al*. (2020) further demonstrated that government support plays a moderating role, strengthening the positive impact of entrepreneurial finance on new venture success, thereby emphasizing the interplay between finance and external support mechanisms. Despite recent advances, there is a pressing need for more inclusive studies that consider a broader range of financing options and their implications for growth across diverse industries. Many existing studies tend to focus predominantly on high-tech industries, potentially overlooking the role of entrepreneurial finance in other sectors that also hold significant potential for growth of firms (Jacob *et al*., 2024). While substantial study exists on the importance of venture capital, the impact of other forms of financing, such as debt financing, equity, crowdfunding, and government grants, on growth still needs to be explored. Besides, the prevailing mechanism often needs an inclusive understanding of how different financing mechanisms interact with various contextual factors, such as regulatory environments and cultural attitudes, to influence innovation outcomes. This gap highlights the need for more inclusive studies that consider a broader range of financing options and their implications for innovation across diverse industries. There is a lack of comprehensive empirical studies that explore the interplay

between different forms of financing and the various circumstantial factors such as regulatory environments, market conditions, and cultural attitudes that influence their effectiveness. This omission is particularly critical as the impact of entrepreneurial finance is likely to vary significantly across different regions and industries, depending on these contextual variables. Furthermore, while the theoretical frameworks employed in recent study have provided valuable intuitions, they often rely on linear models of growth that may not fully capture the iterative and complex nature of modern entrepreneurial processes. This gap suggests a need for more nuanced concepts that consider the non-linear, dynamic interactions between finance, growth, and external factors, thereby offering a more holistic understanding of how entrepreneurial finance can be optimized to support sustainable innovation across various sectors. This study addresses the identified gaps by offering a more comprehensive analysis of how entrepreneurial finance influences innovation across various sectors and contexts. Unlike previous research that predominantly focuses on high-tech industries and venture capital, this study will explore the impact of various alternative financing mechanisms, such as debt financing, equity crowd-funding, and government grants, on innovation within traditional and non-traditional sectors. The novelty of this research lies in its holistic

approach, which integrates the exploration of contextual factors such as regulatory environments, cultural attitudes, and market conditions— into the analysis of entrepreneurial finance. By considering these variables, the study aims to provide a more nuanced understanding of how different forms of financing interact with external conditions to promote or hinder innovation. The primary research questions driving this study are: How can entrepreneurial finance be optimized to support sustainable innovation across diverse sectors? What are the specific challenges and opportunities faced by entrepreneurs in accessing various forms of financing, and how do these factors influence their ability to innovate? To what extent do contextual factors, such as regulatory frameworks and cultural attitudes, affect the relationship between entrepreneurial finance and innovation outcomes? The objective of this research is not just to add to the academic discourse, but to develop practical recommendations for entrepreneurs, investors, and policymakers to enhance the effectiveness of entrepreneurial finance in fostering innovation. By addressing these questions, this study aims to fill the gaps in existing literature, offering new insights into the complex dynamics between finance, innovation, and external contextual factors, ultimately contributing to the development of more effective strategies for supporting entrepreneurial growth and innovation across different sectors

Research Questions

What is the extent of relationship between crowd-funding and growth of microfinance banks in Kogi East, Nigeria?

Is there a degree of correlation between debt financing and growth of Microfinance banks, Kogi East, Nigeria.

To what level is there a relationship between venture capital and growth of microfinance banks, Kogi East, Nigeria

2. Literature Review

Conceptual Review

Concepts of Entrepreneurial Finance

Entrepreneurial finance focuses on the financial aspects of starting and growing new ventures. It involves securing funding, managing financial resources and making strategic financial decisions to maximize a company's value and achieve its goals. Entrepreneurs face diverse financial options when seeking to fund their ventures, ranging from traditional sources like bank loans and personal savings to contemporary avenues such as venture capital, angel investment, and crowdfunding (Ermawati, 2024). Traditional financing methods, such as bank loans, offer

stability and familiarity but often have stringent requirements, including collateral and strict repayment terms (Wang & Yang, 2016). In contrast, contemporary forms of financing, like venture capital, provide access to substantial funds and potential strategic guidance but also come with trade-offs, including equity dilution and the loss of some control over strategic decisions (Cumming & Johan, 2019). Venture capital is beautiful for startups looking to scale quickly, as it injects significant capital in exchange for equity ownership. This funding can drive rapid growth, but it also comes with pressures to meet aggressive targets, potentially prioritizing short-term gains over long-term sustainability (Gompers *et al*., 2020).Angel investors offer early-stage ventures financial support and industry expertise, helping them navigate the initial growth phases. However, this involvement can lead to ownership dilution and potential conflicts of interest (Saona *et al*., 2020). Conversely, crowdfunding democratizes access to capital by allowing entrepreneurs to raise funds from a large pool of individual investors. Success on crowdfunding platforms often depends on effective marketing and community engagement, making it a viable option for entrepreneurs who can galvanize public support (Zeco et al., 2014).The financing choice significantly influences entrepreneurial decision-making and shapes the trajectory of startups. Research shows that

startups backed by venture capital tend to grow faster and achieve higher valuations than those relying on bootstrapping (Gornall & Strebulaev, 2022). However, the influx of venture capital brings the expectation of rapid growth, which can create tension between immediate profitability and longterm sustainability. In contrast, bootstrapped startups retain greater autonomy and control over their operations but may need more resources to scale (Eriksson et al., 2024). Angel investment provides a middle ground, offering financial support and mentorship while allowing founders to retain a degree of control over strategic decisions (Schmidt et al., 2018). The accessibility of these various forms of finance varies based on factors such as industry sector, geographic location, and the stage of venture development. Startups in technology-intensive industries, for example, are more likely to attract venture capital due to their high growth potential and scalability (Stayton & Mangematin, 2019). Additionally, startups in innovation hubs like Silicon Valley benefit from a dense network of investors, mentors, and industry peers, facilitating access to capital and talent (Fuerlinger & Garzik, 2022). However, entrepreneurs in less-developed regions or niche markets often need help securing external funding, leading them to rely on personal savings or informal networks for financial support (Audretsch et al., 2019).Addressing these disparities in access to

finance requires coordinated efforts from policymakers, investors, and ecosystem enablers. Creating inclusive financing mechanisms and support structures for underserved entrepreneurs is crucial for bridging the gap and ensuring that all entrepreneurs have the opportunity to realize their potential (Cumming *et al*., 2021). The entrepreneurial finance landscape is complex and multifaceted, with each funding option presenting its own advantages and challenges. Entrepreneurs must navigate this landscape carefully, aligning their financial strategies with their business goals to manage their capital needs effectively and mitigate the risks associated with external funding (Simanjuntak, 2024). As entrepreneurs continue to explore various financing options, understanding the nuances of each and leveraging supportive ecosystems will be essential for positioning their ventures for growth and innovation. Fostering collaboration among stakeholders and promoting financial inclusion will be vital in building robust and resilient entrepreneurial ecosystems that empower entrepreneurs to drive positive societal change.

CROWDFUNDING

This is a platforms, for example, that allows entrepreneurs to raise capital from a broad pool of individual investors, effectively democratizing access to funding and circumventing traditional financial gatekeepers (Ahlers *et al*., 2015). Peer-to-peer lending platforms similarly facilitate direct lending between individuals, eliminating intermediaries and simplifying the borrowing process for entrepreneurs (Ofir & Tzang, 2022). Additionally, digital banking solutions provide greater convenience and accessibility, enabling entrepreneurs to manage their finances, access credit, and conduct transactions more efficiently (Lottu *et al*., 2023).These microfinance banks enabled solutions have leveled the playing field for entrepreneurs, particularly those facing systemic barriers to traditional financing. By leveraging technology, entrepreneurs can tap into a broader range of funding sources, regardless of their geographic location or socioeconomic background, also, many of these microfinance banks take businesses closer to entrepreneurs at their door spots and ensure their needs are met. Microfinance banks have also promoted greater financial inclusion by providing underserved communities access to affordable and transparent financial services, empowering new entrepreneurs to pursue their business aspirations and contribute to economic growth (Makina, 2019). However, despite the potential of microfinance banks to democratize access to finance, challenges remain in ensuring equitable distribution and widespread adoption. Digital literacy, regulatory compliance, and cyber security are significant obstacles, particularly for marginalized communities with limited access

to technology and education (Choudhary & Bansal, 2022). Data privacy and consumer protection concerns also highlight the need for robust regulatory frameworks to safeguard users' interests and build trust in microfinance banks platforms (Aldboush & Ferdous, 2023).

Entrepreneurial Finance and Growth

Entrepreneurial finance plays a crucial role in driving growth and catalyzing the conception, development, and commercialization of novel ideas and technologies a firm as well as microfinance bank needs to become highly competitive. Study consistently shows that venture capital funding significantly impacts the growth activities of startups, with ventures backed by venture capital more likely to invest in research and development (R&D) initiatives and pursue disruptive growths than their bootstrapped counterparts. This dynamic is mainly due to venture capitalists' financial flexibility and strategic guidance, which enable startups to take calculated risks and explore unconventional ideas with greater confidence (Bonini & Capizzi, 2019). Vibrant entrepreneurial ecosystems further enhance the success of entrepreneurial ventures in fostering growth. These ecosystems are characterized by the convergence of critical elements, including access to risk capital, a diverse pool of skilled talent, robust infrastructure, and a supportive network of mentors and advisors (Spigel, 2017). Within these dynamic environments, startups are equipped with the essential resources and guidance needed to navigate the complex journey of growth, from idea conception to successful market implementation. Such comprehensive support structures empower emerging ventures to overcome obstacles and seize opportunities, fostering an ecosystem that thrives on creativity and ingenuity. Entrepreneurial ecosystems facilitate the exchange of ideas and knowledge, serving as catalysts for cross-pollination of innovation and fostering collective learning among participants that breeds the growth of a firm (Stam, 2015). These ecosystems become breeding grounds for transformative breakthroughs and paradigm shifts across various industries by providing a platform where diverse perspectives intersect. The collaborative ethos inherent in these environments encourages entrepreneurs to venture into uncharted territories, challenging conventional wisdom and driving the emergence of disruptive innovations that reshape markets and propel economic growth. Developing robust entrepreneurial ecosystems also hinges on supportive government policies and regulatory frameworks. Governments play a critical role in creating an enabling environment for entrepreneurship by enacting policies that incentivize investment in high-risk, high-reward ventures and facilitate the flow of capital to innovative startups (Alon-Beck, 2018). Additionally, regulatory frameworks that foster competition safeguard

intellectual property rights and ensure transparency and accountability are essential for building confidence and trust among investors and entrepreneurs (Bruton et al., 2015). These measures create a stable and predictable environment for entrepreneurial activity, attracting investment and fostering sustainable growth within entrepreneurial ecosystems

Theoretical Review.

The theories reviewed were Compensatory Theory of Profits, Traditional Theory of Capital Structures, Pecking Order Theory and Liquidity Preference Theory but compensation theory of profits was adopted as a result of the essentials of this theory to the study.

Empirical Review

Drobetz *et al*, (2024) conducted a study on Entrepreneurial finance and sustainability: Do institutional investors impact the ESG performance of SMEs in Hungary? The study uses survey method with a sample size of 240 respondents with simple random sampling as sampling technique. Institutional investors improve the environmental, social, and governance (ESG) performance of small- and medium-sized enterprises (SMEs). Our difference-in-differences framework shows that the backing from private equity and venture capital funds leads to an increase in SMEs' externally validated ESG scores compared to their matched non-investorbacked

peers. Consistent with "ESG-as-insurance" theory, the ESG performance of SMEs with a higher probability of failure is more likely to benefit from the backing of institutional investors. This positive effect is heterogeneous; while SMEs with high ex-ante ESG performance further improve their ESG performance following institutional investor backing, SMEs with low ex-ante ESG performance are unlikely to implement any improvements. Entrepreneurial finance seems to help sustainable entrepreneurs transform into "sustainability champions," while neglecting the betterment of non-sustainable SMEs.

Min (2024) investigated a study on the bright side of social trust and entrepreneurial finance in Canada. He adopted survey method of data collection with over 460 sample size and SPSS version 26 using regression analysis as method of data analysis. A growing number of studies in the past two decades suggest that social trust matters for financing. However, a few recent studies also indicate that social trust may result in systemic biases and opportunistic behavior. First, we show that trust is important for several types of entrepreneurial financing. Second, our results reveal that trust plays an essential role in start-up financing in places with low access to information, low disclosures, and weaker legal protection. However, in countries with stronger legal protections, the effect of trust is either insignificant or negative. Hence, trust

takes on the role of a substitute and may not necessarily bring benefits when strong formal institutions are present.

Mario, Samuele & Valerio (2025) carried out a study family friends entrepreneurial finance: The case of corporate venture capital in Italy. The study made the use of systematic review as from 2000 to 2017 which originated from family firms. We show that families are an engine of venturing activities: almost 30 percent of corporate venture capital (CVC) deals in the US Family firms, primarily those led by family CEOs, orchestrate CVC activities differently than non-family firms: they syndicate more often and with more reputable investors, join larger syndicates, and make more proximate deals (geography- and industry-wise). This approach to corporate venturing maps into performance results: family CVC-backed ventures exhibit a higher likelihood of successful exit. Collectively, our results shed light on the important, and largely unexplored, role of family firms in CVC.

3. Methodology

The study is carried out in Itobe, Kogi State, Nigeria, a fast developing economy in the easter part of Kogi State. A self-structured questionnaire adopted from previous literature (Hadizadeh, 2013; Nawab *et al*. 2015) on five–point Likert scale was used to generate data to investigate the relationship between entrepreneurial finance adopted and growth of microfinance banks in the competitive environment. To ensure the face and content validity of the research instrument, three experts in the field studied and offered appropriate suggestions which were carried out. For the reliability of the instrument, Cronbach Alpha's was used to test the items in the questionnaire. The coefficient result was 0.89 which is high enough to consider the instrument reliable for the study (Bruce and Kay, 1978). A pilot study was conducted on 10 microfinance banks with test–re-test result of PearsonMoment Correlation Coefficient of 80%. The sampling frame consisted of 20 employees and management of microfinance banks, Giddens (1983) selection formulae was used to obtain the sample size. The simple random sampling method where everyone has the equal chance of being selected was employed to select the sample size of two hundred and forty (240) respondents, but only two-hundred and twenty-five (225) respondents responded. Descriptive statistics, Pearson-Moment Correlations and Multiple regression analytical technique were used for analysis.

The Dependent Variable:

Growth was measured with the increase in customer base as well as number of activities carried out in a shortest time, that is, the ability of microfinance banks to have more customers, locations, outlets and branches as a result of new ideas employees of microfinance banks used, which had in the past five years as obtainable in some activities (Uzor, 2021;

Okwo *et al.* 2019). That is, how increase in customer base determine growth and how many customers patronize the microfinance banks and number of employees do they take in each year in the past 5 years (2000-2025). Therefore, the increase in number of customer base, locations or branches as well as increase in employees or staff strength was considered a useful measure of growth.

Independent Variables:

The Entrepreneurial finance that were used are crowd-funding, Venture Capital, as well as Debt financing were measured with 3 items each based on growth of microfinance banks, availability of data base for knowledge storage, the methods of documentation of expert's knowledge, means of acquisition, assimilation and storage of conference/training materials; means of conversion and storage of entrepreneurial finance. Respondents were at liberty to choose between the ranks of 5 to 1 with highest score 50 and least score 10. Crowd-funding was measured with one-on-one access to capital or pool of finances, market or community engagement, use of A total of 3 items were raised and respondents are at liberty to choose between the ranks of 5 to 1.

Debt financing was measured with sales of bonds, stocks, bills of note as well as investors creditors' use of B total of 3 items were raised and respondents are at liberty to choose between the ranks of 5 to 1.

The study was conducted in Itobe, Kogi State, Nigeria, a fast-developing area in the eastern part of the state. Data was generated using a self-structured questionnaire adapted from previous studies (Hadizadeh, 2013; Nawab et al., 2015) on a five-point Likert scale to examine the relationship between tacit knowledge transfer methods and employee competitiveness in woodwork firms.

To ensure validity, three experts in the field reviewed the instrument and provided suggestions, which were incorporated. Reliability was tested using Cronbach's Alpha, which yielded a coefficient of 0.89, indicating high reliability (Bruce & Kay, 1978). A pilot study was also conducted on 60 woodwork firms, with a test–retest Pearson Moment Correlation result of 0.80.

The sampling frame consisted of producers and workers in microfinance banks, and Giddens' (1983) formula was applied to determine the sample size. A simple random sampling technique was employed, resulting in a target sample of 246 employees, of which 225 responded. Data was analyzed using descriptive statistics, Pearson Moment Correlation, and multiple regression techniques.

4. Results and Discussion of Findings

4.1 Descriptive Data Analysis

This section presented a brief profile of the sample 246' employees of Microfinance banks

in Kogi East, Kogi State, Nigeria. It explained the general features of the respondents.

The study adopted face to face survey method with a sample size of 246.

Table 1: Respondents by response rate

Response	Frequency	Percentage
LAPO (a) MFB	80	15.4
ASHA (b) MFB	66	25.5
FMBC MFB (c) workers	98	50.8
Respondents who MFBs with all (d)	2	7.8
		100
Total	246	89.5
Summation of MFBs (a+b)	146	65.4

Summation of workers of Microfinance Banks (a+d) 48

Source: Authors' work, 2025

From Table 4.1, the respondents that produce Microfinance Banks were 246, LAPO were 80, ASHA were 66, FCMB were 98 and those that work with all were 48. This indicated that respondents work with all the Microfinance Banks. However, the more respondents used LAPO. (15.4%) than ASHA (25.5%) and FCMB (50.8 %). This supported the finding of Awwal (2017) in which Microfinance banks operate with different logo and names were most patronized industry with 50.8% (FCMB) having 25.5% in LAPO and 48% in ASHA while all who use entrepreneurial finance were 7.8%.
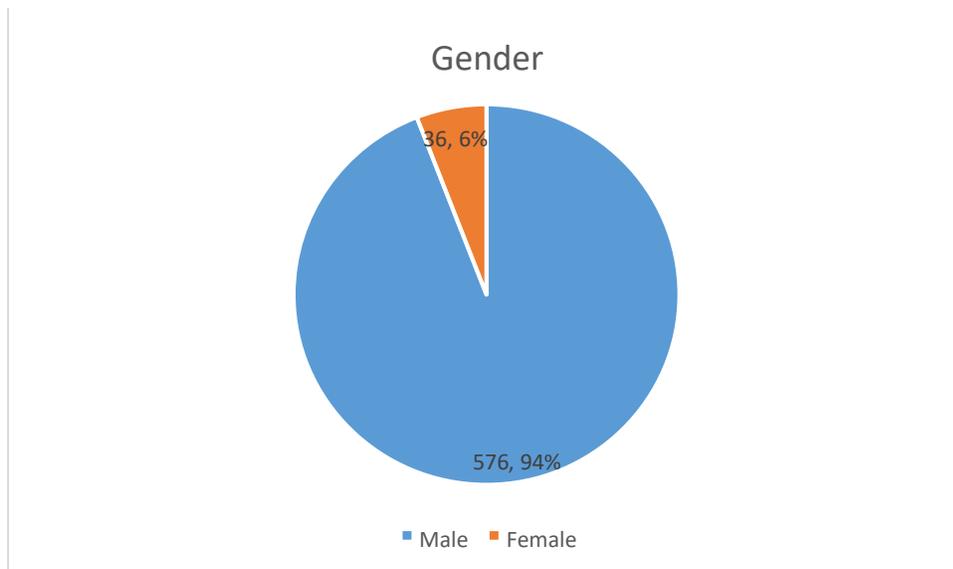
Figure .1 Distribution of Respondents by gender

 Source: Author's work, (2025)

Figure 1 showed that 36 respondents of the sample size are female while 94 of the respondents are male which indicated an uneven distribution of gender in the use of entrepreneurial financein Kogi East,, Nigeria. Men are more predominantly involved in the MFBs activities than women, this could be as a result of men physique and natural ability that is, there are more men who make use of entrepreneurial finance than the female counterpart involved in MFBs. Hence, May, et al (2019) male use natural endowment and capability to ensure works are easily done especially works that involve technical skills and capabilities like MFBs. Microfinance Banks ensure entrepreneurial finance is adequately considered through crowd-funding, venture capital and debit financing and relearning (Arowsoge and Tee, 2010).
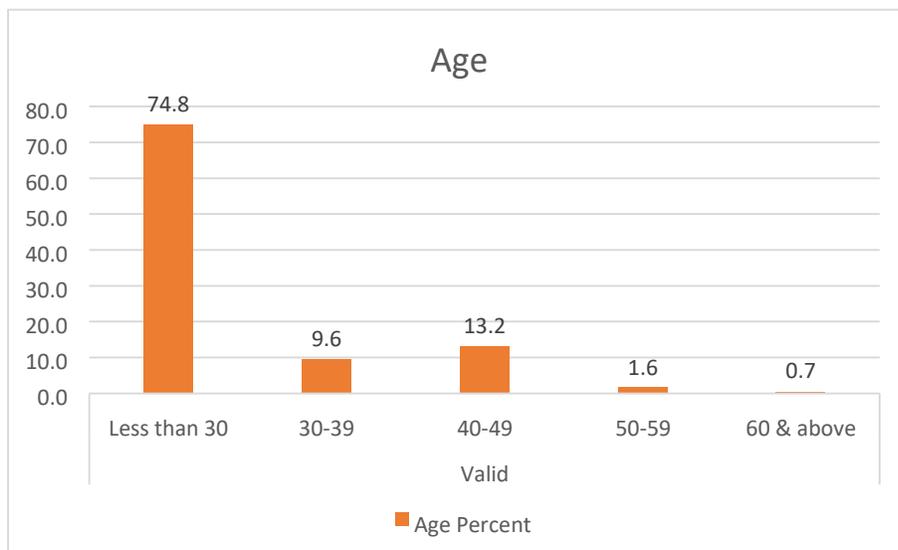
Figure 2: Distribution of Respondents by Age

Source: Author's work, (2025)

Figure 2 revealed the percentage distribution of the age distribution of respondents that the majority are less than 30 years (74%) followed by 40-49years (13.2%), followed by 50-59 years (1.6%) but the least is 60 years above (0.7%) in the MFBs. This implies that most of the employees and more suitable for the study. This supports Ameh (2020) assertion that young people dominate the MFBs and reason for more creativity seen in the industry more than others. MFBs are actively in operation due to the nature of people who engage themselves in the operation of the firm (Adejoh, 2021). Employees of various firms need to make use of knowledge acquired in making the firms known to the people in order to engage more persons at the place of discharging their duties which helps to achieve more growth in the firms. Today, across mainstream, young people hunger for success and greatness as a result of competition within the environment and therefore, the easiest way to make it is through a well demanding business (Seid, 2021).

Factor loading

Presenting the factor loadings of constructs within the measurement model serves as the initial step in assessing the measurement model (Hair *et al*., 2019). This involves both the graphical and tabular presentation of factor loading values for each item within the considered constructs of the measurement model. Items with loading values below 0.5 and above 0.95 were typically deleted.

Table 2: Summary of Cronbach Alpha and Composite Reliability of Measurement Instrument

Constructs (Entrepreneurial Finance)	Cronbach's alpha (standardized)	Cronbach's alpha (unstandardized)	Composite reliability (rho_c)
Crowd-funding	0.790	0.780	0.793
Debt Financing	0.751	0.748	0.751
Venture Capital	0.763	0.757	0.769
Growth	0.889	0.847	0.843

Source: Researcher, 2025

Table 3: Summary of Cronbach Alpha and Composite Reliability of Measurement Instrument

Variables	Cronbach's alpha (standardized)	Cronbach's alpha (unstandardized)	Composite reliability (rho_c)
Crowd-funding	0.790	0.780	0.793
Debit Financing	0.751	0.748	0.751
Venture Capital	0.76	0.73	0.91
Growth	0.889	0.847	0.843

Source: Researcher, 2025

Table 4. : Convergent validity

Variables	Average variance extracted (AVE)
Crowd-funding	0.581
Debit Financing	0.501
Venture Capital	0.562
Growth	0.614

Source: Researcher, 2025

Table 4.10 provides insights into the constructs' Average Variance Extracted (AVE) scores, which gauge the amount of variance captured by the construct's measurement items. The constructs, namely Crowd-funding (Crwdfun), Debit Financing (DebFin), Venture Capital (VenCap) and Growth of Microfinance Banks (GOWWF), each have corresponding AVE values. The AVE is a critical indicator for assessing the convergent validity of the measurement model. Analyzing the AVE values reveals varying degrees of convergent validity across the constructs. Notably, Cowdfunding (Crwdfun) stands out with the highest AVE score, suggesting that a substantial proportion of the variance in its measurement items is accounted for by the underlying construct. On the other hand, Venture Capital (VenCap) has the lowest AVE value among the constructs.

While all AVE values fall below the ideal threshold of 0.5, they are still indicative of an acceptable level of convergent validity, demonstrating that each construct captures a reasonable amount of shared variance among its items.

Model

$$\text{GRTH}_{(1-5)} = \beta_0 + \beta_1 \text{Crwdfun}_{(1-5}\beta_5\text{DebFin}_{(1-3)}\beta_3\text{VenCap}, \mu ---$$

Hypothesis testing

H_i: there is no positive significant relationship between crowd-funding and growth of Microfinance Banks

H_{ii}: there is no positive significant relationship between Venture Capital and Growth of Microfinance Banks

H_{iii}: there is no positive significant relationship between Debit Financing and Growth of Microfinance Banks

	Unstandardized coefficient		Standardized coefficient	Sig
	B	STD Error	Beta	
Constant	0.182	1.137		0.000
Crowd fundin-	0.50	0.660	0.541	0.031
Venture Capital	0.34	0.44	0.412	0.042
Debit Finance	0.67			
	0.69			
R	0.63			
R-square				
Adjusted R-Square	0.69			
F-Value	10.322			

SPSS 26.0

Table 1 above shows the linear regression analysis result between, Crowd-funding and growth of Microfinance banks in Kogi East. There is a significant positive relationship between Crowdfunding and growth, it shows that a unit increase in crowd-funding of microfinance banks will lead to 0.50 improvement in growth of Microfinance Banks. The result is in agreement with the finding of (Jacob *et al*, 202024) who found a significant relationship between crowd-funding and growth of SMEs. The R^2 shows that the model explained 69% of the total variance as a whole while other variables (such as government regulations, market conditions, and entrepreneurial culture) not mentioned in the model explained 31%. The

F-statistics (10.332) shows a good model fit, the result is highly significant at $P<0.1$. Therefore, the null hypothesis is rejected. Also, the result shows that Venture Capital has a positive effect on the growth of Microfinance Banks in Kogi-East which is significant at 0.05 level of significant. The result indicates that a unit increase in Venture Capital will lead to 0.34 increase in growth of Microfinance Banks in Kogi-East, Kogi State. This is also in agreement with the work of (Larisa, 2021) who found a significant relationship between Venture Capital and growth of Woodwork firms. Based on the findings, the null hypothesis was rejected.

Besides, there is a significant positive relationship between Debit Financing and growth of Microfinance Banks in Kogi East, Kogi State, it shows that a unit improvement in debit financing of microfinance banks will lead to 0.67 improvement in growth of Microfinance Banks. The result is in agreement with the finding of (Suleiman *et al*, 2025) who found a significant relationship between debit financing and growth of Dangote Cement PLC. The R^2 shows that the model explained 69% of the total variance as a whole while other variables not mentioned in the model explained 31%. The F-statistics (10.332) shows a good model fit, the result is highly significant at $P<0.1$. Therefore, the null hypothesis is rejected.

Conclusion/Recommendation

This study reconnoitered the composite dynamics between entrepreneurial finance and growth of Microfinance Banks, emphasizing how various financing forms such as venture capital, crowdfunding, and debt financing affect Microfinance Banks Growth. The study further examined the role of circumstantial factors, including government regulations, market conditions, and entrepreneurial culture, in shaping the effectiveness of financing in

promoting growth of Microfinance Banks. The findings underscore the critical importance of both financial resources and external conditions in driving entrepreneurial success. The originality of this study lies in its comprehensive analysis of how different forms of entrepreneurial finance interact with relative factors to influence innovation across various sectors. This research contributes to the academic understanding of entrepreneurial finance and offers practical insights for policymakers, investors, and entrepreneurs. By identifying the key drivers of growth and the barriers that must be addressed, this study provides actionable recommendations for creating a more inclusive and effective entrepreneurial finance. The implications for practice and policy are significant, suggesting that targeted financial strategies and supportive regulatory environments are essential for fostering sustainable innovation and economic growth. However, this study has limitations that should be considered in future research.

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AI and the Transformation of Social Interaction: Exploring the Impact of Intelligent Systems on Relationships, Communication, and Community Life

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Abstract

Artificial Intelligence (AI) has increasingly become a central component of human communication, social relationships, and community engagement. This study explores how intelligent systems—such as chatbots, virtual assistants, recommendation algorithms, and social robots—are transforming traditional patterns of social interaction. Using a qualitative documentary analysis approach, the review synthesizes existing literature to identify key themes related to AI-mediated communication, emotional relationships, algorithmic influence, and community dynamics. Findings reveal that AI enhances communication efficiency and personalisation while also introducing challenges such as reduced interpersonal depth, algorithmic bias, privacy concerns, and overdependence on machine-mediated interaction. The study concludes that AI is reshaping, rather than replacing, human social behaviour and emphasizes the need for ethical, human-centered approaches to ensure technology strengthens meaningful connections. Recommendations are offered for policymakers, developers, educators, families, and researchers.

Keywords: Artificial Intelligence, Social Interaction, Communication, Relationships, Community Life

1. Introduction

Artificial Intelligence (AI) has rapidly evolved from a technical innovation into a major social force shaping human behaviour, communication practices, and community structures (Ayodele et al., 2023). In today's digitally connected world, intelligent systems such as chatbots, virtual assistants, social robots, recommendation engines, and algorithm-driven social platforms mediate a significant portion of everyday interactions. These technologies are no longer limited to industrial or computational tasks; they now influence how individuals form relationships, express emotions, access information, and participate in social groups. As a result, AI is increasingly viewed not only as a technological tool but as a sociological agent that subtly influences human interaction patterns (Khan, 2020).

The integration of AI into daily life is evident across various domains. Social media platforms rely heavily on AI algorithms to personalise content, determine visibility of posts, and shape user engagement. Messaging platforms employ predictive text and automated responses that streamline communication while subtly guiding conversational tone (Shubham, 2024). In professional environments, AI-based collaboration tools facilitate remote meetings, automate scheduling, and support team interaction, thereby influencing organisational culture and reducing the need for face-to-face

contact. Even within households, smart devices and digital assistants mediate family interactions, influence routines, and act as intermediaries between users and the digital ecosystem (Bastidas Junco, 2024).

As AI becomes embedded in these everyday practices, it transforms traditional patterns of social interaction by creating new modes of communication and altering long-standing interpersonal norms. Individuals increasingly rely on conversational AI for emotional support and companionship, use algorithmic recommendations to make social choices, and participate in online communities heavily shaped by automated moderation (Mariani et al., 2023). These shifts raise critical sociological questions about authenticity, social cohesion, emotional well-being, digital dependency, and the future of human relationships. They also challenge conventional theories of communication and socialisation, prompting a re-examination of how human identity and social behaviour evolve in technology-mediated environments (Jia et al., 2024).

Furthermore, AI's influence extends beyond interpersonal exchanges to broader societal dynamics. Issues of algorithmic bias, digital inequality, privacy, surveillance, and the commodification of personal interaction reflect deeper structural concerns about power and governance in the digital age (Tai, 2020). As AI-driven systems continue to mediate

communication and social organisation, they have the potential to both strengthen and weaken social bonds, depending on how they are designed and implemented. This duality makes the study of AI and social interaction an urgent and important topic for sociologists, policymakers, educators, and technologists (Brandao, 2025).

This paper explores how AI reshapes social interaction across interpersonal, relational, and community levels. It examines both the opportunities and challenges presented by AI-driven communication and highlights the need for responsible adoption to ensure technology enhances, rather than diminishes, meaningful human connection. The analysis further emphasizes the importance of a human-centered approach to AI integration, one that preserves empathy, authenticity, and social cohesion in an increasingly automated world.

2. Literature Review

Artificial Intelligence (AI) has become increasingly integrated into social life, prompting scholars across sociology, communication studies, and technology ethics to investigate its impact on human interaction. Existing literature highlights both the transformative potential of AI and its complex sociocultural implications.

2.1 AI and Human Communication

Scholars such as Hartford and Stein (2024) argue that AI-driven communication tools influence how people express themselves and relate to others. The rise of conversational agents such as chatbots, virtual assistants, and generative AI has introduced new forms of mediated interaction. These systems provide companionship, emotional support, and immediate responses, creating what researchers describe as "simulated social presence." Walther's (2011) work on computer-mediated communication suggests that digital environments shape self-presentation and interpersonal behaviour, a concept now expanded to include interactions with AI systems.

2.2 AI in Personal and Emotional Relationships

Research indicates that AI affects emotional intimacy and relationship patterns. Saracini et al. (2025) found that users often treat computers as social actors, attributing human-like qualities to digital systems. Modern studies show that individuals can form emotional bonds with AI companions, especially when experiencing loneliness or social isolation. While these interactions may offer psychological comfort, critics warn that reliance on AI for emotional fulfilment could weaken human-to-human relationship skills and reduce authentic social engagement (Smith et al., 2025).

2.3 AI, Social Media, and Algorithmic Influence

Social media platforms use AI algorithms to filter content, recommend connections, and personalize user experiences. According to Dahlgren (2021),

this personalization creates "filter bubbles," in which individuals are exposed primarily to information that aligns with their existing preferences. This influences social interaction by shaping opinions, reinforcing group identities, and sometimes promoting polarization. Steiglechner et al. (2023) theory of the network society underscores how digital infrastructures structure human relationships, a dynamic amplified by AI-driven content curation.

2.4 AI in Community and Organisational Settings

Studies also highlight the growing role of AI in community formation and workplace communication. AI moderates online groups through automated content filtering, enhances community mobilization through targeted messaging, and supports workplace collaboration through scheduling assistants, chatbots, and virtual meeting tools. While these technologies increase efficiency, sociologists caution that they may reduce spontaneous social interactions and reshape organisational culture (Jothy, 2025).

2.5 Ethical and Social Concerns in AI-Mediated Interaction

Scholars emphasise ethical challenges associated with AI-mediated communication, including privacy, algorithmic bias, surveillance, and overdependence on intelligent systems (Hanna et al., 2024). Zuboff (2019) warns that AI-enabled data collection transforms everyday interactions into opportunities for surveillance capitalism.

Meanwhile, concerns about bias highlight how AI systems may reinforce existing inequalities in visibility, representation, and access to information (Hart et al., 2025).

2.6 Literature Gaps

Although existing research provides valuable insights, several gaps remain:

1. Limited studies examine long-term effects of AI on interpersonal relationships.
2. Few investigations explore cultural variations in AI-mediated social behaviours.
3. The role of AI in redefining community belonging and cohesion requires deeper analysis.

This paper seeks to contribute to filling these gaps by examining AI's influence on social interaction at interpersonal, relational, and community levels.

3. Methodology

This study adopts a qualitative research design to explore the impact of Artificial Intelligence (AI) on social interaction, communication patterns, and community life. Given that AI's influence is primarily social, relational, and behavioural, a qualitative approach provides the depth needed to understand the nuances of human experiences and sociological interpretations.

3.1 Research Design

The study employs an exploratory research design. This approach is appropriate because AI-driven social interaction is an emerging field with limited empirical consensus. Exploratory design allows for the identification of patterns, themes, and conceptual relationships that may inform further empirical investigations.

3.2 Data Collection Method

A documentary analysis method was used. This involved reviewing existing literature, research reports, policy papers, journal articles, and academic books related to:

i.   AI and human communication,
ii. AI-mediated relationships,
iii. AI-driven social platforms, and
iv. Sociological theories of technology and interaction.

This method enabled a comprehensive understanding of how scholars conceptualize the relationship between AI and social interaction.

3.3 Data Analysis Technique

Data were analysed using **thematic content analysis**. The procedure involved:

1. **Reading and coding** major ideas from selected sources;
2. **Grouping similar ideas** into thematic categories such as interpersonal communication, emotional relationships, algorithmic influence, and community interaction;
3. **Interpreting themes** through sociological theories such as symbolic interactionism, social presence theory, and network society theory;
4. **Synthesizing findings** into a coherent narrative that reflects the broader social implications of AI.

3.5 Ethical Considerations

Since the study relies on secondary sources, no direct human participation was involved. However, ethical considerations were upheld by:

i.   Ensuring accurate referencing of all consulted materials,
ii. Avoiding plagiarism through proper citation,
iii. Maintaining the integrity of the original authors' ideas.

3.6 Limitations of the Methodology

While documentary analysis provides useful insights, it has limitations:

i.   It depends entirely on the availability and quality of existing literature.
ii. It may not fully capture rapidly evolving developments in AI technology.
iii. It does not include primary empirical data such as interviews or observations.

Despite these limitations, the methodology offers a strong foundation for understanding the sociological implications of AI-mediated interactions.

4. Findings and Discussion

The thematic analysis of existing literature reveals that Artificial Intelligence (AI) is significantly transforming social interaction on three interconnected levels: interpersonal communication, social relationships, and community life. These findings highlight both the opportunities and challenges associated with AI-mediated interactions.

4.1 AI and Interpersonal Communication

The literature indicates that AI systems increasingly mediate interpersonal communication. Tools such as chatbots, predictive text, real-time translation, and virtual assistants simplify communication and enhance accessibility.

Key findings include:

i. **Increased reliance on AI for everyday communication:** Users depend on conversational agents for answers, emotional exchanges, and decision-making support.

ii. **Reduced communicative complexity:** Smart replies and auto-generated messages speed up communication but may weaken expressive depth and originality.

iii. **New communication norms:** AI-mediated communication introduces new patterns such as shortened messages, reduced face-to-face interaction, and increased digital dependency.

These findings support earlier work by Geladi (2018) , who argues that technology shapes how people converse and perceive connection.

4.2 AI and Social Relationships

AI's influence extends beyond simple communication to the quality and structure of social relationships.

Major findings include:

i. **Emergence of AI companionship:** Individuals form emotional attachments to AI systems—especially those experiencing loneliness, social anxiety, or long-distance communication barriers.

ii. **Shift in family dynamics:** Smart home devices and AI learning tools reduce direct interactions, divert attention, and restructure household routines.

iii. **Algorithmic shaping of friendships:** Social media algorithms determine what users see, who they connect with, and how social bonds develop.

These shifts reflect the "media equation" principle proposed by Saracini et al. (2025),

which suggests that humans instinctively treat AI as social actors.

4.3 AI in Community Life and Collective Interaction

Communities, both digital and physical are increasingly shaped by algorithm-driven systems.

Key findings include:

i. **Content curation and community identity:** AI algorithms influence what trends, opinions, and cultural elements define online communities.

ii. **Automated moderation:** AI moderates online group discussions, reducing harmful content while raising concerns about transparency and bias.

iii. **Transformation of workplace communities:** AI-enabled scheduling, communication tools, and workflow automation reshape interaction patterns, sometimes weakening spontaneous social bonding.

Steiglechner et al. (2023) network society theory helps explain how AI-driven platforms act as the new infrastructure for community formation and engagement.

4.4 Social and Ethical Challenges

Across all levels of interaction, the findings reveal several emerging concerns:

4.4.1 Privacy and Surveillance Risks

AI systems capture vast amounts of personal data, leading to increased surveillance and potential misuse.

4.4.2 Algorithmic Bias and Inequality

AI may reinforce existing social inequalities through biased recommendations, discriminatory content filtering, or unequal representation online.

4.4.3 Overdependence on AI

Relying heavily on AI for social connection may reduce interpersonal skills, emotional intelligence, and the ability to maintain meaningful human relationships.

4.4.4 Authenticity and Emotional Depth

Interactions mediated by AI may lack the emotional richness of human-to-human engagement, raising questions about authenticity and empathy.

4.5 Synthesis of Discussion

The findings reveal that AI is neither purely beneficial nor purely harmful; rather, it functions as a powerful social force that transforms interaction patterns. The key implication is that AI does not replace human communication but reconfigures it, altering how people connect,

form relationships, and participate in community life.

Understanding these changes is vital for policymakers, technologists, educators, and sociologists who seek to promote responsible and human-centered AI integration.

5. Conclusion and Recommendations
5.1 Conclusion

This study examined the transformative impact of Artificial Intelligence (AI) on social interaction, highlighting how intelligent systems shape communication, relationships, and community life. Findings from the literature show that AI has become deeply embedded in everyday social processes. It enhances communication efficiency, provides companionship, personalizes social experiences, and facilitates community engagement. However, it also raises concerns about reduced human-to-human interaction, emotional detachment, algorithmic bias, privacy risks, and the potential weakening of authentic social bonds.

Overall, AI does not merely support communication—it actively redefines it. As societies continue integrating intelligent systems, understanding their sociological implications becomes critical for maintaining meaningful human connection, protecting social values, and ensuring equitable technology use.

5.2 Recommendations

Based on the findings of this study, it is recommended that policymakers and regulators develop clear frameworks governing data privacy, algorithmic transparency, and ethical AI deployment. Regulations should aim to prevent discriminatory AI practices and protect vulnerable social groups, ensuring that AI systems support rather than replace human interaction. Educators and social institutions should integrate digital literacy and AI awareness into curricula, equipping students with the skills to balance AI-mediated communication with interpersonal competencies. Technology developers are encouraged to prioritize human-centered AI designs that foster meaningful social connections, improve transparency in algorithmic decision-making, and involve sociologists and behavioral scientists in the design process. Families and individuals should adopt mindful AI usage practices, balancing the convenience of intelligent systems with real-life interactions to maintain emotional depth and interpersonal skills. Finally, researchers should conduct empirical studies examining the long-term effects of AI on relationships and community cohesion, explore cultural differences in AI-mediated social behaviors, and investigate strategies for leveraging AI to strengthen social bonds. Collectively, these measures can help ensure that AI contributes positively to communication, relationships, and community life without

undermining the quality of human social interaction.

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Explicature in the 2024 #EndBadGovernance Protests in Nigeria: A Pragmatic Analysis

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Abstract

This paper examines explicature in the 2024 #EndBadGovernance protest placards in Nigeria through the lens of Relevance Theory and Gricean Pragmatics. Explicature—the explicit proposition derived after contextual enrichment—serves as a crucial mechanism through which short, emotionally charged placard texts communicate complex political meanings. Using a corpus of 100 placards collected during nationwide demonstrations and corroborated by news and photojournalistic evidence, the study explores how Nigerian protesters encoded explicit propositions about governance failure, economic hardship, and political accountability. A qualitative multimodal pragmatic analysis was employed to identify how linguistic and visual cues (ellipsis, deictic expressions, typography, color) constrained and guided hearers' inferential processes. Findings reveal that (1) slogans rely heavily on shared socio-political context to produce complete explicatures; (2) placard designers compress detailed grievances into minimalist textual forms enriched by context; and (3) multimodal resources heighten the salience of particular explicit propositions. The paper concludes that explicature offers a productive framework for understanding protest communication in digital-era movements, as it foregrounds how minimal language becomes a full proposition through contextual and cognitive operations. Implications are drawn for pragmatic theory, protest discourse, and African political communication.

Keywords: explicature, Relevance Theory, pragmatics, protest discourse, #EndBadGovernance, Nigeria

1. **Introduction**

The 2024 #EndBadGovernance protests marked one of Nigeria's largest civic uprisings since #EndSARS in 2020. Sparked by fuel-subsidy removal, currency devaluation, and worsening living costs, thousands of citizens flooded major cities—Lagos, Abuja, Kaduna, Port Harcourt—to demand policy reversal and leadership accountability (Al Jazeera, 2024; Reuters, 2024). Placards bearing terse inscriptions—*"Enough is Enough," "Hunger Is Killing Us," "We Are Not Slaves in Our Country"*—became emblematic of the movement. These linguistic artefacts condensed elaborate grievances into short, media-friendly expressions.

While political scientists and journalists have examined the protests' causes and outcomes (Amnesty International, 2024; FIJ, 2024), fewer linguistic studies have explored how meaning was communicated through these placards. Existing pragmatic research often centers on implicature or presupposition, overlooking explicature—the explicit content recoverable once context supplies missing information (Sperber & Wilson, 1986, 1995). Because protest signs must be interpretable instantly, explicature becomes indispensable: it allows incomplete textual forms to yield fully propositional political messages.

This study therefore asks:

How do placards construct explicit propositions (explicatures) from minimal linguistic material?

Which pragmatic and multimodal cues guide hearers toward these explicatures?

How does shared socio-political knowledge influence explicature derivation?

The answers illuminate the interface between cognitive pragmatics and political activism in contemporary Africa.

2. Theoretical Framework

2.1 Gricean foundations

Grice's (1975) Cooperative Principle and conversational maxims (Quality, Quantity, Relation, Manner) provide the foundation for pragmatic meaning. Speakers and hearers collaborate to make utterances relevant and interpretable. Protest slogans, however, deliberately violate maxims of Quantity and Relation—using minimal language to invite inferential recovery.

2.2 Relevance Theory and explicature

Sperber and Wilson (1986, 1995) redefine explicit meaning as explicature, the output of linguistic decoding plus pragmatic enrichment. For example, *"Enough is Enough"* becomes *"The government's mismanagement has become intolerable and must stop."* Explicature differs from implicature in that the latter adds new assumptions, while the former completes underspecified ones. Protest placards exemplify this enrichment process: reference resolution ("who?" → government), time anchoring ("now,"

"2024"), and causal inference ("because of economic hardship").

2.3 Multimodality and contextual constraints

Following Kress and van Leeuwen (2006) and Machin and Mayr (2012), protest texts are multimodal ensembles where typography, color, gesture, and imagery work with language to cue inference. Multimodal pragmatic theory (Forceville & Urios-Aparisi, 2009) extends Relevance Theory across semiotic modes: a red background signals urgency, a clenched-fist icon indexes resistance. Each visual element narrows possible explicatures.

2.4 Common ground

Clark (1996) and Stalnaker (2002) define common ground as the shared knowledge enabling interlocutors to compute meaning. In protests, shared cultural scripts ("bad governance," "corruption," "fuel subsidy") allow protesters and observers to enrich slogans rapidly. Without this common ground, many placards would remain semantically incomplete.

3. Data and Methodology

3.1 Corpus description

The dataset comprises 100 placards collected by the researcher during the 2024 #EndBadGovernance protests, supplemented by verified photojournalistic sources (Reuters, Getty Images, Al Jazeera, Channels Television). Each placard was transcribed, contextualized (location, date), and coded for linguistic and visual variables.

3.2 Analytical procedure

A qualitative multimodal pragmatic analysis was used:

Identify the literal linguistic content.

Infer the minimal proposition.

Enrich the proposition via contextual assumptions (social, political, visual).

Differentiate explicature from implicature.

Inter-coder validation was conducted with two pragmatic scholars to enhance reliability.

3.3 Ethical considerations

Only public images were analyzed; no personal identifiers were retained. The study follows the ethical recommendations of Amnesty International (2024) regarding protest documentation.

4. Analysis and Findings

4.1 Minimal slogans and contextual enrichment

Slogans such as *"Enough is Enough"* present skeletal syntax. Contextual enrichment supplies:

Agent = government/leadership

Predicate = must stop corruption and economic hardship
→ Explicature: "The Nigerian government's bad governance has reached an intolerable limit and must cease immediately."

This reconstruction aligns with media headlines citing inflation and subsidy removal as core grievances (FIJ, 2024; Al Jazeera, 2024).

4.2 Deictic alignment and collective pronouns

Placards reading *"We Are Not Slaves in Our Country"* foreground first-person plural deictics ("we," "our"). These pronouns index collective agency and shared victimhood, yielding the explicature: "Citizens reject subjugation by political elites." Such explicitness arises only through contextual grounding in Nigeria's post-colonial governance discourse.

4.3 Nominal and imperative structures

Nominal slogans (*"Fuel Subsidy Must Be Back"*) employ deontic modality (*must*) to produce prescriptive explicatures: "The government should reinstate the fuel subsidy." Imperatives (*"Stop Killing the Poor"*) encode explicit directives.

4.4 Metaphor, humor, and hyperbole

Metaphors like *"One day the poor will eat the rich"* explicitly predict social upheaval, while implicitly warning of class conflict. The explicature is moderated—inequality is extreme and unsustainable—while the implicature conveys a threat of revolution.

4.5 Multimodal salience

Visuals intensify explicit propositions:

Empty plates → reinforce hunger claims.

Red typography → signals danger and urgency.

National flag motifs → anchor patriotism as explicit motive.

Such multimodal cues enhance relevance by guiding viewers toward intended explicatures (Forceville & Urios-Aparisi, 2009).

4.6 Cross-platform circulation

Many placards migrated to social media, where hashtags and captions recontextualized them. For instance, #EndBadGovernance posts paired *"Hunger Is Killing Us"* with inflation statistics, making the explicature explicit even for global audiences.

4.7. Discussion

Three insights emerge:

Explicature as core meaning: Unlike implication-based approaches, explicature foregrounds how minimal linguistic cues become explicit political propositions. This underscores protesters' strategic efficiency: they exploit inferential enrichment to produce maximum meaning with minimal form.

Multimodal interaction: Placards are designed for camera circulation; visual salience ensures that explicatures survive decontextualization in news and online feeds. Thus, pragmatic analysis must integrate visual semiotics.

Common ground and reception: Shared socio-economic grievances create predictable enrichment pathways. Where audiences lack such

knowledge, explicature becomes unstable, producing divergent interpretations.

The study advances Relevance Theory by showing explicature's role in collective political discourse rather than dyadic conversation, aligning with recent pragmatic extensions (Carston, 2002; Wilson & Sperber, 2012).

5. Conclusion and Recommendations

Explicature analysis reveals how Nigerian protesters transform minimal text into fully explicit propositions. Through contextual enrichment, shared knowledge, and multimodal cues, placards communicate precise claims about governance, inequality, and policy demands.

Future research should:

Compare explicature stability across socio-economic groups.

Apply quantitative corpus-linguistic tools to larger multimodal datasets.

Investigate how explicatures evolve when signs are remediated online.

Understanding explicature in protest communication contributes both to pragmatic theory and to the documentation of democratic expression in the Global South.

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Common Grounds in the #EndBadGovernance Protests in Nigeria: A Hybrid Pragmatic–Discourse Analysis

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Abstract

The 2024 #EndBadGovernance protest in Nigeria represented a nationwide eruption of civic frustration against persistent economic hardship, systemic corruption, and political exclusion. This study investigates the common grounds—the shared beliefs, assumptions, and communicative resources—that unified diverse participants across ethnic, regional, and socio-economic divides. Employing a hybrid analytical framework that integrates Critical Discourse Analysis (CDA) and Common Ground Theory (CGT), the study explores how protesters' linguistic choices, slogans, and digital discourse constructed a collective consciousness of discontent and reform. A corpus of 100 protest placards, complemented by selected social media texts and media reports, was qualitatively coded for thematic, pragmatic, and ideological patterns. Findings reveal that the protests coalesced around four macro-common grounds: economic precarity, governance failure, democratic accountability, and youth inclusion. Pragmatic analysis shows how explicit and implicit meanings in protest expressions indexed solidarity, moral legitimacy, and socio-political urgency, while CDA exposes the intertextual links between popular grievances and structural narratives of power. The study concludes that the #EndBadGovernance movement rearticulated Nigerians' moral economy of governance, transforming private suffering into a public moral claim. The paper contributes to African discourse scholarship by demonstrating how hybrid pragmatic–critical models illuminate the communicative infrastructures of social movements.

Keywords: #EndBadGovernance; common ground; protest discourse; Critical Discourse Analysis; Nigeria

1. Introduction

The 2024 #EndBadGovernance protests in Nigeria marked one of the most significant episodes of civic mobilisation in the post-#EndSARS political landscape. Triggered by widespread economic hardship following the removal of fuel subsidies, currency devaluation, and escalating inflation, the protests transcended class, ethnic, and regional boundaries to articulate a collective indictment of governance failure. Demonstrations erupted across major Nigerian cities between 1 and 10 August 2024, uniting youths, civil society actors, and labour movements under the digital banner of the hashtag **#EndBadGovernance**.

Beyond expressions of spontaneous anger, the protests exhibited a coherent communicative logic. Placards, chants, and online texts presupposed shared assumptions about corruption, insecurity, economic mismanagement, and democratic betrayal. This convergence reflects what discourse scholars describe as **common ground**—the mutual knowledge, beliefs, and presuppositions that enable collective meaning-making (Clark, 1996). Understanding how such common ground operated within the #EndBadGovernance movement is crucial to explaining its national resonance and communicative effectiveness.

This study is guided by the following research questions:

1. What ideological and socio-economic themes constituted the common grounds of the 2024 #EndBadGovernance protests?

2. How did pragmatic and linguistic features of protest discourse construct shared meanings of governance failure?

3. How can a hybrid framework combining Critical Discourse Analysis and Common Ground Theory enhance the study of protest communication in African contexts?

By integrating pragmatic and critical perspectives, the study bridges the gap between micro-level meaning negotiation and macro-level social power. It aligns with African discourse traditions that conceptualise language as both a communicative and political instrument (Adegoju, 2015; Odebunmi, 2021). The analysis foregrounds how ordinary Nigerians deployed language to reclaim agency and moral legitimacy in the face of institutional authority.

2. Literature Review

2.1 Protest Communication in Africa

Research on African political communication consistently highlights protests as discursive events through which citizens renegotiate the social contract (Obi, 2022; Oloruntoba, 2023). In contexts where institutional dialogue is weak or

inaccessible, public demonstrations function as alternative arenas of deliberation. Nigerian protest culture—from the "Ali Must Go" protests of 1978 to the 2020 #EndSARS movement—illustrates a longstanding tradition of rhetorical contestation and civic expression (Adebanwi, 2017).

Language in protest performs multiple functions, including mobilisation, identity construction, and moral persuasion. Fraser (2020) argues that African protest movements deploy "vernacular moralities" that blend indigenous expressions with democratic ideals. The #EndBadGovernance protests exemplify this pattern, combining everyday linguistic forms with demands for accountability, justice, and inclusion.

2.2 Common Ground and Pragmatic Meaning in Collective Action

The concept of common ground refers to the shared beliefs and assumptions that enable coordinated communication (Clark & Brennan, 1991; Stalnaker, 2002). In protest discourse, common ground manifests when speakers assume mutual recognition of injustice, hardship, and state responsibility. Recent pragmatic studies demonstrate how protesters co-construct shared frames of reference that sustain collective identity and action (Mey, 2016; Kecskes, 2019).

In the Nigerian context, protest placards frequently rely on presuppositions about economic hardship, corruption, and governance failure to generate relevance. Utterances such as

"No food, no peace" presuppose shared knowledge of hunger and state neglect, functioning simultaneously as explicatures and implicatures within a shared pragmatic environment (Carston, 2002; Sperber & Wilson, 1995).

2.3 Critical Discourse Analysis and Power

Critical Discourse Analysis (CDA) conceptualises language as a social practice that both reflects and reproduces power relations (Fairclough, 1995; van Dijk, 2008). In protest studies, CDA reveals how citizens contest dominant narratives of legitimacy and governance. Through lexical choices, metaphor, and intertextuality, protest discourse exposes ideological struggles embedded in everyday language (Wodak & Meyer, 2016).

Studies of Nigerian protest discourse show that metaphors of hunger, decay, and illness recurrently frame leadership failure (Adegoju, 2015; Odebunmi, 2021). The #EndBadGovernance placards extend this repertoire by deploying humour and irony to challenge official narratives of reform and progress.

2.4 Hybrid Analytical Models

Recent developments in discourse studies increasingly advocate hybrid analytical approaches that integrate pragmatic analysis with critical perspectives in order to capture the full complexity of socio-political communication (Cap & Okulska, 2013; Fetzer & Bull, 2022). This

shift responds to the recognition that meaning in political discourse is not produced solely at the level of linguistic form or inference, nor can it be fully explained by ideology and power structures alone. Rather, political meaning emerges through the interaction of contextual inference, shared knowledge, and discursive power relations.

Pragmatics focuses on how speakers and hearers construct meaning beyond literal expressions, emphasizing inference, relevance, presupposition, implicature, and shared context. It explains how minimal or indirect utterances become meaningful through contextual enrichment. However, while pragmatic approaches excel at explaining *how* meaning is inferred, they often pay limited attention to *why* certain meanings dominate, whose interests they serve, or how language reinforces or challenges power. This limitation has prompted scholars to combine pragmatics with Critical Discourse Analysis (CDA), which conceptualizes language as a social practice embedded in ideology, dominance, and resistance (Fairclough, 1995; van Dijk, 2008).

CDA provides tools for uncovering how discourse constructs social realities, legitimizes authority, and reproduces or contests power relations. By examining lexical choices, metaphors, intertextual references, and framing strategies, CDA reveals the ideological work performed by discourse. When combined with pragmatics, it allows analysts to trace how micro-level meaning-making processes (such as implicature or presupposition) connect to macro-level social struggles, including governance failures, marginalization, and resistance.

Such hybridity is especially crucial for African socio-political texts, where communication often relies on linguistic economy, cultural allusion, humour, irony, and indirect critique. In contexts where overt confrontation with authority may attract repression, speakers frequently encode dissent through pragmatic strategies that presuppose shared socio-political knowledge. Hybrid models therefore offer a more sensitive and context-aware framework for analysing how meaning operates simultaneously at interpersonal and ideological levels.

The #EndBadGovernance protest corpus, characterized by the use of English, Nigerian Pidgin, and frequent code-switching, exemplifies this complexity. Protest placards and digital texts are typically brief, elliptical, and highly context-dependent, requiring pragmatic interpretation grounded in shared experiences of economic hardship, corruption, and political exclusion. At the same time, these texts perform ideological work by challenging dominant narratives of reform, progress, and legitimacy promoted by political elites. A purely pragmatic analysis would risk overlooking this ideological dimension, while a purely critical approach might underplay the inferential processes that make such texts intelligible and persuasive.

The integration of Common Ground Theory and Critical Discourse Analysis therefore offers a robust and complementary framework for capturing the interaction between interpersonal alignment and structural dissent. Common Ground Theory explains how shared assumptions, collective memories, and mutual beliefs enable protesters to communicate complex meanings with minimal text, while CDA situates these meanings within broader struggles over power, representation, and governance. Together, they allow for a holistic analysis of protest discourse as both a cognitive-pragmatic and socio-political phenomenon.

By adopting this hybrid analytical model, the present study aligns with contemporary discourse scholarship and provides a theoretically grounded approach for examining how protest language in Nigeria functions as a site of meaning negotiation, ideological resistance, and civic engagement.

2.5 Empirical Studies on #EndBadGovernance

Although academic research on the 2024 #EndBadGovernance protests is still at an early stage, emerging reports and preliminary studies consistently identify youth mobilisation, digital activism, and shared socio-economic grievances as the defining features of the movement (Amnesty International, 2024; African Liberty, 2025). These accounts portray the protests as a nationwide expression of frustration with rising inflation, fuel subsidy removal, currency devaluation, unemployment, and perceived governance failure. Importantly, they highlight how the protests cut across ethnic, religious, and regional divisions, suggesting the presence of a strong unifying force in the movement's communicative practices.

Several empirical commentaries emphasise the central role of social media platforms—particularly X (formerly Twitter), Facebook, and Instagram—in facilitating mobilisation, coordination, and message amplification. Youth-led digital activism enabled rapid circulation of protest slogans, placard images, hashtags, and short commentaries that condensed complex political grievances into accessible and emotionally resonant messages. Amnesty International (2024), for instance, documents how online discourse sustained protest momentum even in the face of state repression, while African Liberty (2025) frames the movement as a digitally mediated demand for economic justice and accountable governance. These studies demonstrate that protest communication operated simultaneously in physical and digital spaces, reinforcing shared meanings across audiences.

Despite these insights, existing empirical works largely approach the protests from sociological, political, or human-rights perspectives, paying limited attention to the linguistic and pragmatic mechanisms through which unity was discursively constructed. Where language is mentioned, it is often treated descriptively—as slogans, chants, or hashtags—rather than

analytically. Consequently, little is known about how protesters relied on implicit meanings, presuppositions, shared knowledge, and contextual inference to communicate powerfully with minimal text. The ways in which placards and short slogans achieved coherence, relevance, and national resonance through pragmatic processes remain underexplored.

Furthermore, current studies rarely theorise the concept of *common ground* as an explanatory tool for understanding protest cohesion. While shared grievances are acknowledged, they are not systematically analysed as mutually recognised assumptions that enable protesters to communicate effectively without explicit elaboration. Similarly, the interaction between explicit meanings (what placards overtly say), implicit meanings (what they suggest or accuse indirectly), and broader ideological contestation is often overlooked. This gap limits our understanding of how protest discourse functions as both a communicative and political instrument.

The present study addresses these shortcomings by offering a systematic empirical analysis of #EndBadGovernance protest placards through a hybrid pragmatic–critical framework. By integrating Common Ground Theory and Critical Discourse Analysis, it moves beyond descriptive accounts to explain *how* unity is linguistically produced and sustained. In doing so, the study contributes original empirical evidence to the growing body of scholarship on the #EndBadGovernance movement and provides a robust linguistic explanation for the communicative power and national resonance of the protests.

3. Methodology

3.1 Research Design

The study adopted a qualitative descriptive design within a hybrid analytical framework combining Common Ground Theory (Clark, 1996; Stalnaker, 2002) and Critical Discourse Analysis (Fairclough, 1995; van Dijk, 2008). This approach enabled an examination of how protest language simultaneously draws on shared background knowledge and resists institutional power.

3.2 Data Corpus

The data for this study consisted of a corpus of 100 protest texts drawn from both physical and digital spaces. Specifically, the corpus comprised:

- 50 physical protest placards photographed during demonstrations in Abuja, Lagos, Port Harcourt, and Lokoja; and

- 50 social media posts sourced from Twitter (X), Facebook, and Instagram, tagged with the hashtags #EndBadGovernance and #WeMove.

Purposive sampling was employed to ensure analytical relevance. Only publicly accessible texts that explicitly critiqued governance,

economic conditions, or political leadership were included. This approach ensured that the data reflected authentic protest communication intended for public consumption rather than private commentary. Each placard or social media post constituted a single unit of analysis.

3.3 Data Processing and Coding

All physical placards were digitised and transcribed verbatim. Non-standard orthography, abbreviations, emojis, and Nigerian Pidgin expressions were deliberately retained to preserve the authenticity and pragmatic force of the texts. Social media posts were similarly transcribed, with attention paid to hashtags, emphatic punctuation, and multimodal cues where relevant.

The data were manually coded using NVivo 14, following an iterative coding process. Coding categories were informed by both pragmatic and critical concerns and included:

- shared socio-political knowledge (common ground),
- pragmatic implicature,
- explicature and contextual enrichment,
- ideological resistance, and
- solidarity markers such as collective pronouns and inclusive expressions.

This dual coding framework allowed the study to capture both inferential meaning and ideological positioning.

3.4 Analytical Procedure

The analysis proceeded in three interrelated stages. First, each placard or post was examined to identify complete meaning units and key linguistic features. Second, pragmatic interpretation was conducted to determine explicatures and implicatures based on contextual assumptions shared by protesters and their audience. Third, discursive evaluation linked these pragmatic meanings to broader ideological functions, such as resistance, blame attribution, solidarity construction, and power inversion.

Triangulation was achieved by cross-referencing interpretations with media reports and contemporaneous social media commentary. This helped ensure contextual accuracy and strengthened the validity of the analytical claims.

4. Findings and Discussion

The findings demonstrate that #EndBadGovernance protest discourse relied heavily on shared socio-political knowledge, intertextual memory, and pragmatic inference. Many placards presupposed collective awareness of Nigeria's economic decline, making explicit explanation unnecessary. Expressions such as *"Hunger no be democracy"* and *"Dollar don win naira again"* draw their force from widely shared experiences of inflation, food insecurity, and currency devaluation.

Intertextual references to earlier movements, particularly #EndSARS, activated communal memory and reinforced continuity in civic struggle. Slogans referencing past protests functioned as reminders that grievances were unresolved rather than new. Pragmatic implicatures further enabled protesters to criticise state authority indirectly, often through humour, irony, or understatement, thereby reducing the risk of overt confrontation while maximising communicative impact.

From a CDA perspective, linguistic choices frequently inverted power relations and foregrounded citizen agency. The use of Nigerian Pidgin, metaphors of suffering, and collective pronouns ("we," "our") positioned protesters as morally legitimate actors confronting an unresponsive political elite. Together, these strategies illustrate how pragmatic meaning and ideological resistance converge to transform brief, economical texts into powerful instruments of dissent.

5. Conclusion and Recommendations

The study demonstrates that the communicative power of the 2024 #EndBadGovernance protests was grounded in shared common grounds that transformed individual suffering into collective moral claims. By integrating Common Ground Theory with Critical Discourse Analysis, the research provides a multidimensional account of how protest language functions as both pragmatic action and ideological resistance.

5.1 Theoretical Contribution

The hybrid framework advances African discourse scholarship by linking pragmatic inference to struggles over meaning and legitimacy.

5.2 Practical Implications

Understanding shared background knowledge can enhance civic communication strategies and improve public engagement with protest discourse.

5.3 Future Research

Future studies should expand the corpus, incorporate multilingual analysis, and explore longitudinal comparisons with earlier protest movements.

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