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EDITORIAL

Presenting the first edition of the third volume of the Journal of Multidisciplinary Research and Innovations (JMRI) gives me great excitement and fulfilment after months of labour. It is not just that another publication is out; but our long-awaited dream has been achieved and the JMRI's reach has expanded beyond limits. We give all the glory to God who has been our help.

As indicated in the foregoing, JMRI is now an online publication showcasing both previous and the current editions. All this has been made possible by the commitment of the Academic Staff Union of Polytechnics, The Federal Polytechnic, Bida Chapter (ASUP-BD) through the Chapter Executive Council (CEC) to whom we say a very big congratulations on the achievement of this feat. We acknowledge the institution – the Federal Polytechnic, Bida - and its Management for this positive development. Journal of Multidisciplinary Research and Innovations (JMRI) is breaking boundaries and it is our hope that all enabling environments will continue to be accorded her to remain relevant in dispersing knowledge and *Promoting Research Integrity*.

This volume has maintained the multidisciplinary nature of the journal, living true to its name. Articles cover the broad areas of Arts and Humanities; Business and Management; Engineering and Sciences; and Environmental Studies. Researchers, the academia, and all knowledge loving individuals would find the articles contained in it useful and relevant to their search.

The Editorial Board is much commended for their sacrificial tenacity towards ensuring success in this assignment. I thank everyone who contributed to the making of this volume and specially congratulate all authors. ASUP-BD CEC are specially appreciated for every encouragement all the way. We are grateful to our families for support.

Papers are being received for the next edition of this volume. Do not be left out. The next volume will be published in December, 2026. All contributors should carefully note and comply with the guidelines. The online publication has come to stay. We will keep the flag flying.

Thank you.



Dr. O.I. Ajari
Editor-in-Chief

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ARTS AND HUMANITIES



FORM, FORCE, AND INDIGENOUS FORMALISM: A CRITICAL EDITION OF “EWO GBOKA” BY LATE ALHAJI HAMZA SONFADA BIDA

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ABSTRACT

This paper presents a carefully developed critical edition of “Ewo Gboka” (“Money is Strong”), a notable Nupe oral composition attributed to Alhaji Hamza Sonfada Bida. While African oral texts have often been approached mainly from anthropological and sociological perspectives, this study shifts attention to the internal artistic qualities of the composition. Using a Formalist lens, the paper explores its structural, phonological, and poetic features. Drawing on the ideas of Jakobson (1960) and Shklovsky (1965), the analysis shows that “Ewo Gboka” functions not only as a song, but also as poetry, philosophical reflection, and socio-economic commentary. Through tonal patterning, repetition, gradual variation, and metaphorical expression, the composition demonstrates a refined indigenous formal system comparable to written poetic traditions. The paper also contributes to the preservation of Nupe oral literature through annotated transcription and critical explanation.

Keywords: Nupe oral literature; Formalist criticism; tonal poetics; African aesthetics; wealth symbolism; critical edition.

INTRODUCTION

Nupe oral literature represents one of the most intellectually rich expressive traditions in Middle Belt Nigeria. As noted by Nadel (1942), Nupe society developed complex political, artistic, and philosophical systems that supported a vibrant oral culture. This tradition includes praise poetry, hunters’ narratives, didactic songs, and reflective performances expressed in a highly tonal language.

Within this tradition, “Ewo Gboka” holds a special place. Attributed to Alhaji Hamza Sonfada Bida, the composition reflects deeply on the meaning, power, and social implications of wealth. Rather than treating the piece simply as a cultural artefact, this paper considers it as a structured literary work worthy of detailed critical attention.

The objectives of this study are threefold:

1. To produce a reliable and annotated critical edition of “Ewo Gboka.”
2. • To examine its structural, phonological, and stylistic features.
3. • To situate the composition within African oral poetics and broader Formalist theory.

LITERATURE REVIEW

The study of African oral literature has gradually moved from early descriptive accounts to more analytical and

interdisciplinary approaches. Early scholars such as Nadel (1942) focused largely on social and cultural documentation, often presenting oral texts as reflections of society rather than as artistic creations in their own right. While this work remains valuable, it tends to overlook the internal organisation and aesthetic depth of oral compositions.

Finnegan (2012) made an important contribution by arguing that oral literature should be recognised as a legitimate form of literature. She highlights the importance of performance, audience interaction, and the flexible nature of oral texts. Although her work acknowledges stylistic richness, less attention is given to close formal analysis of structure, sound patterns, and repetition.

Formalist scholars such as Jakobson (1960) and Shklovsky (1965) provide useful tools for addressing this gap. Jakobson’s idea of the poetic function draws attention to how language is organised, particularly through repetition, balance, and patterning. Shklovsky’s concept of defamiliarisation explains how literature makes familiar ideas appear fresh and striking. Although these ideas were developed in relation to written texts, they are equally relevant to oral traditions.

Recent scholarship has increasingly recognised that African oral traditions are governed by their own artistic systems. These include tonal arrangement, call-and-

response patterns, rhythm, and gradual development of ideas. Such features show that oral compositions are carefully shaped and artistically controlled, rather than being spontaneous or unstructured.

Despite this progress, there are still relatively few studies that combine Formalist theory with detailed analysis of specific African oral texts. This gap is particularly noticeable in studies of Nupe literature. This paper therefore contributes by offering both a critical edition and a close formal analysis of “Ewo Gboka.”

THEORETICAL FRAMEWORK

Formalism and the Poetic Function: This study adopts a Formalist perspective, especially Jakobson’s (1960) idea of the poetic function. This approach focuses on how meaning is shaped through structure, repetition, and balance. In “Ewo Gboka,” these features help transform reflections on wealth into a patterned and memorable poetic form.

Defamiliarisation and Metaphorical Expression: Shklovsky (1965) argues that literature renews perception by presenting familiar ideas in unexpected ways. In this composition, money is not treated as an abstract concept but as something with weight, presence, and power. This makes the idea of wealth more vivid and engaging.

Indigenous Formalism: Although Formalist theory developed in Europe, similar principles are evident in Nupe oral traditions. The use of tone, repetition, rhythm, and variation reflects an established indigenous system of artistic expression.

METHODOLOGY

This study uses a qualitative and interpretive approach, combining textual analysis with insights from performance practice. The aim is to produce a reliable and culturally grounded critical edition of “Ewo Gboka.”

Data Sources: Primary data were obtained through performance reconstruction and semi-structured interviews with knowledgeable individuals familiar with Nupe oral traditions. Secondary data include relevant scholarly literature and theoretical texts.

Sampling Technique: Participants were selected purposively based on their experience and knowledge of Nupe oral performance.

Data Collection Methods: Data were gathered through interviews, oral recitations, and comparison of different versions of the composition.

Analytical Procedure: The study involved reconstructing the text, analysing its formal features, and interpreting its meaning within its performance context.

Editorial Conventions

Tonal Marking: High (á), Mid (ā), Low (à).

- Orthographic standardisation based on current conventions.
- Glossing and commentary provided for clarity.

Validity and Reliability: Credibility was ensured through triangulation, participant feedback, and comparison of multiple sources.

5. Nupe Tonal Poetics Nupe is a tonal language in which pitch affects meaning. In “Ewo Gboka,” tone also contributes to artistic expression. Key features include alignment with rhythm, consistency across repetition, and emphasis through tonal rise.

Critical Text and Annotated Transcription: Stanza I: The Weight of Wealth Nupe Text: Éwò gbóká, éwò nùkú bí bà mí

Translation: Money is strong; money is a heavy burden upon my back.

Commentary: Repetition highlights the central idea and reinforces rhythm.

Stanza II: Spatial Reach Nupe Text: Ewo gba u d’anyi, u gba u d’aba Ewo doko kpe le, u nyi le ma

Translation: Money reaches the east and the west; it extends everywhere.

Commentary: The imagery suggests the wide influence of wealth.

Stanza III: Social Power Nupe Text: Ewo-gi nyi kpa, kolo ma ya Ewo-gi fe nyi doko, zuma ma sa

Translation: The wealthy speak and people gather; where wealth exists, authority follows.

Commentary: Wealth is presented as a source of influence and control.

Stylistic and Structural Analysis: The composition uses simple but powerful language, repetition, and gradual development of ideas to create impact. Rhythm and performance further enhance its meaning.

Ethnomusicological Context: The performance setting—often communal gatherings—reinforces the message and encourages audience participation.

CONCLUSION

“Ewo Gboka” shows that Nupe oral compositions are carefully structured and artistically rich. The paper highlights the need to recognise and preserve such traditions as important forms of literature.

RECOMMENDATIONS

1. Establish archives for preservation.
2. Include oral literature in academic curricula.
3. Promote standardisation of transcription methods.
4. Encourage interdisciplinary research.
5. Support community involvement.

6. Use digital tools for documentation.
7. Provide institutional and policy support.

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DIGITAL MEDIA USAGE TRENDS AMONG GRAPHIC DESIGNERS IN BENIN CITY, EDO STATE, NIGERIA

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ABSTRACT

This study investigates digital media trends among graphic designers in Benin City, Nigeria, drawing on the Technology Acceptance Model (TAM) and Diffusion of Innovation (DOI) Theory to explain patterns of technology adoption. The study adopted a mixed-methods approach involving questionnaires administered to 450 participants and interviews with 25 key informants. Findings revealed a high level of digital media adoption among graphic designers, with 89.3% used professional software and 84.6% relying on social media platforms such as Facebook and Instagram for communication. The study concludes that while digital media enhances graphic design practice, its full potential depends on improved infrastructure and capacity development. The study therefore recommends increased investment in digital infrastructure, affordable software access, and continuous professional training to strengthen digital media utilization among graphic designers.

Keywords: Digital Media; Graphic Design; Mass communication; Technology Adoption; Communication Effectiveness

INTRODUCTION

The evolution of digital media technologies has significantly transformed mass communication, reshaping how information is created, distributed, and consumed. Digital media has shifted communication from traditional linear models to interactive, network-based systems that enhance audience engagement and participation (Zuo, 2023). Within this transformation, Zuo (2023) also claimed that graphic designers have emerged as key facilitators of visual communication, utilizing digital tools and platforms to convey messages across diverse audiences.

Digital media has expanded the scope of graphic design beyond traditional print practices to include interactive, multimedia, and network-based communication. Digital communication technologies have enhanced connectivity and enabled more dynamic forms of information dissemination, thereby increasing the effectiveness and reach of visual communication (Nwambam et al. 2023). This shift has positioned designers as critical actors in contemporary communication systems.

In developing countries such as Nigeria, these global advancements intersect with local realities, where access to technology, infrastructure, and professional training influence the extent of digital media adoption. Benin City, as an active creative hub, provides a relevant context for examining how graphic designers engage with digital media tools and platforms in practice.

Digital Media in Mass communication: Digital media according to Zuo (2023), has significantly transformed the landscape of mass communication, reshaping how information is produced, distributed, and consumed. This claim represents a shift from traditional communication channels such as print, radio, and television to interactive, network-based platforms driven by internet technologies. This transition has enhanced the speed, reach, and accessibility of communication processes, making digital media central to contemporary information exchange.

Nwambam et al. (2023) noted that the integration of digital technologies into mass communication has improved connectivity and facilitated the rapid dissemination of information across diverse audiences; asserting that digital media enables both large-scale and niche communication, fostering engagement within communities defined by shared interests. Similarly, Wahyu and Irawan (2024) argue that digital transformation has expanded the scope of communication by introducing dynamic and interactive forms of visual storytelling. These developments have strengthened communication effectiveness by emphasizing multimedia and motion-based content over static formats.

Graphic Designers as Agents of Mass communication: Graphic designers have evolved into key agents of mass communication, functioning as visual interpreters who translate complex ideas into accessible forms. Their role extends beyond aesthetic production to include strategic

communication, where design is used to inform, persuade, and influence audiences. The integration of design elements within digital media enables designers to achieve sophisticated communication objectives through structured visual system (Nwaoboli & Arijeniwa, 2025).

In practical contexts, graphic designers contribute significantly to public communication efforts. For instance, in health communication, designers create visual materials that address diverse audiences and overcome literacy barriers through culturally relevant imagery. The importance of visual communication became particularly evident during the COVID-19 pandemic, where effective design strategies were essential for disseminating critical health information (Ternenge et al., 2022).

Furthermore, the rise of social media has amplified the role of graphic designers in shaping public discourse. Platforms such as Instagram and Twitter enable designers to produce and distribute content that can mobilize social movements and influence public opinion. The #EndSARS protests in Nigeria illustrate how digital media and visual communication can be leveraged to coordinate collective action and sustain engagement (Uwalaka & Nwala, 2023).

Digital Media Adoption in Developing Countries:

Despite the global expansion of digital media, its adoption in developing countries presents unique challenges. In Nigeria, the integration of digital technologies into communication practice is often constrained by infrastructural limitations, including unreliable internet connectivity and inconsistent power supply (Guanah et al., 2020). These factors affect the efficiency and consistency of digital media usage among professionals.

In addition, disparities in digital literacy pose significant barriers to effective adoption. Alegado (2025) highlights that many potential users lack the necessary skills to fully utilize digital tools, while Sujoko et al. (2023) identify a gap between the demand for digital competencies and the availability of training opportunities. These challenges contribute to uneven levels of adoption and limit the potential of digital media in professional practice.

Challenges in Digital Media Utilization: The utilization of digital media in graphic design is further affected by economic, technological, and socio-cultural constraints. Resource limitations, such as the high cost of professional

software and hardware, restrict access to advanced design tools, particularly among small and medium-scale practitioners (Veza et al., 2023; Moussadecq et al., 2024). These financial barriers hinder the ability of designers to fully exploit digital media capabilities.

Moreover, the digital divide continues to affect both access and quality of digital services, thereby influencing the effectiveness of communication strategies (Sujoko et al., 2023). Beyond technological constraints, cultural considerations also play a significant role. Nwaoboli and Arijeniwa (2025) emphasize that the creation of culturally appropriate and contextually relevant content requires designers to navigate complex social and linguistic dynamics. This challenge is particularly pronounced in digital environments that often prioritize global standards over local specificity.

Despite the growing importance of digital media in graphic design, there remains limited localized, empirical research that captures how these technologies are adopted and utilized within specific environments. The studies by Okoronkwo and Oshionebo (2024); and Shobukonla and Nwabuku (2025) were either institution-specific or limited in scope, leaving gaps in understanding the broader patterns of digital media adoption, communication effectiveness, and contextual challenges among practicing graphic designers in urban creative hubs such as Benin City; thus, necessitating this investigation into digital media trends among graphic designers in Benin City, focusing on adoption patterns, communication effectiveness, and the challenges shaping professional practice with the following specific objectives to:

1. examine the patterns of digital media usage among graphic designers.
2. assess the impact of digital media on communication effectiveness.
3. identify challenges impeding digital media adoption and utilization

seeking to provide answers to the research questions below:

1. What digital media tools and platforms are commonly used by graphic designers in Benin City for mass communication?
2. How does the adoption of digital media influence the effectiveness of mass communication among graphic designers in Benin City?

3. What challenges do graphic designers in Benin City encounter in the adoption and utilization of digital media technologies?

METHODOLOGY: This study is anchored on the *Technology Acceptance Model (TAM)* and the *Diffusion of Innovation (DOI) Theory*, which together explain the individual and social dimensions of digital media adoption among graphic designers.

The Technology Acceptance Model (TAM) posits that technology adoption is primarily determined by *perceived usefulness*—the extent to which a technology enhances job performance—and *perceived ease of use*—the degree to which it is free of effort (Davis, 1989). These constructs influence users' attitudes and behavioural intention toward technology use. TAM explains graphic designers' adoption of digital media tools as a function of their perceived value in enhancing creativity, efficiency, and communication effectiveness, while constraints such as skill gaps and software complexity may affect ease of use.

The Diffusion of Innovation (DOI) Theory explains how innovations spread within a social system over time through communication channels (Rogers, 2003). Contemporary studies further emphasize that diffusion is influenced by social networks, adopter categories, access to infrastructure, and communication processes that shape technology acceptance and usage (Iqbal & Zahidie, 2022). Within this study, digital media tools represent the innovation, while professional networks and digital platforms facilitate their diffusion among graphic designers. Variations in adoption are shaped by peer influence, infrastructural access, and the role of early adopters within the design community. Together, TAM and DOI provide a complementary framework that links individual perceptions with broader social processes, offering a comprehensive basis for analyzing digital media adoption in graphic design practice.

This study adopted a mixed-methods research design to examine digital media trends among graphic designers in Benin City. The approach was considered appropriate as it enables the integration of quantitative data for identifying general patterns with qualitative insights for explaining underlying experiences and contextual factors. It also allows for triangulation, thereby enhancing the validity and reliability of the findings. The population comprised

practicing designers, including freelancers, agency-based, and corporate professionals. Given the absence of a comprehensive sampling frame and the need to engage participants with relevant professional experience, a purposive sampling technique was employed to select respondents who are actively involved in graphic design practice. This was complemented by snowball sampling, where initial participants referred other qualified designers within their networks. A total of 450 respondents were selected for the quantitative phase, while 25 key informants participated in the qualitative interviews. Data were collected using structured questionnaires and semi-structured interview guides, capturing information on demographics, digital media usage, communication effectiveness, and professional challenges. Quantitative data were analyzed using SPSS, descriptive and inferential statistics, while qualitative data were analyzed through thematic analysis. Triangulation was employed to enhance the validity and reliability of the findings.

RESULTS AND DISCUSSION

The findings indicate a predominantly young and digitally oriented workforce as seen in Figure 1, with Generation Z (45.3%) and Millennials (38.7%) forming the majority, alongside a near-balanced gender distribution (52.4% male; 47.6% female) as captured in Figure 2. Most respondents hold bachelor's degrees (67.8%) and are early-career professionals (41.3% with 1–5 years' experience), with freelancing (34.2%) and agency-based practice (28.9%) dominating the employment structure. It is obvious from the findings that graphic design practice in Benin City is dominated by a young and digitally inclined workforce, largely composed of Generation Z and Millennials. This is further reinforced by qualitative insights, where one informant noted: "*Most of us grew into design through digital tools; it is almost impossible to practice without them now.*" This suggests that the profession is being driven by individuals who are inherently familiar with digital technologies. The implication of this demographic structure is that digital media adoption is not incidental but embedded within the professional identity of contemporary designers. Recent studies have shown that younger creative professionals are more likely to integrate digital technologies into their daily workflows due to greater familiarity with digital environments and evolving communication cultures (Sujoko et al., 2023). The near-balanced gender distribution further indicates increasing inclusivity within

the creative industry, reflecting broader shifts toward diversity in digital and media professions. Furthermore, Veza et al. (2023) strongly believes that the dominance of early-career practitioners and freelancers reflects a flexible, decentralized, and evolving creative economy shaped by platform-based work, remote collaboration, and digital entrepreneurship. Digital media adoption is extensive, as Figure 3 reveals high usage of professional tools such as Adobe Photoshop (89.3%) and Illustrator (76.4%), alongside accessible platforms like Canva (72.1%). Social media platforms, especially Instagram (84.6%) and Facebook (71.3%) serve as key channels for communication and promotion. A large proportion of respondents use digital tools for over six hours daily (78.4%) and integrate them into more than 80% of their projects (92.1%), reflecting a strongly digital workflow as shown in Figure 4.

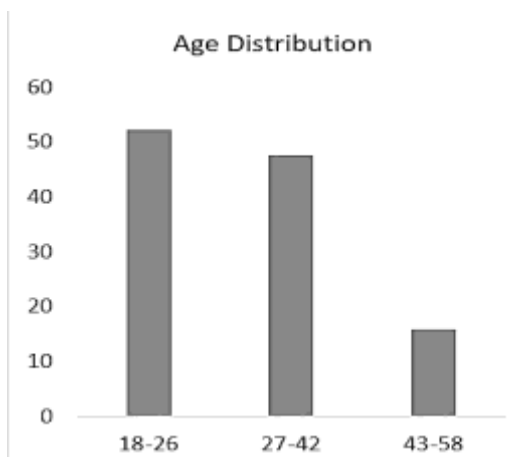


Figure 1. Age distribution of respondents (showing the dominance of younger graphic designers within the study population).

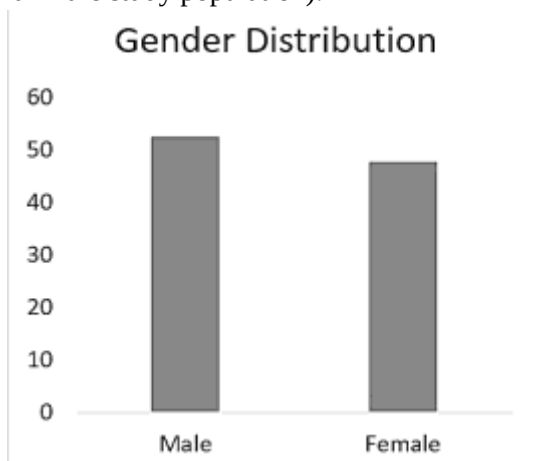


Figure 2. Gender distribution of respondents

(showing a near-balanced representation of male and female graphic designers).

Qualitative responses reveal that designers strategically combine tools based on project demands and client expectations. As one participant explained: *“We use Photoshop for serious design work, but Canva helps when clients want something fast and affordable.”* This shows that digital media tools are deeply integrated into professional practice, with designers relying heavily on

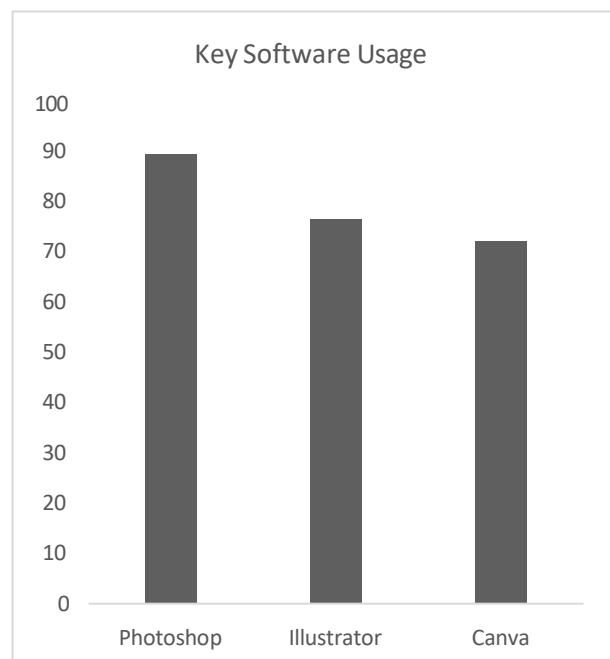


Figure 3. Key software usage among respondents (showing high reliance on professional and accessible digital design tools).

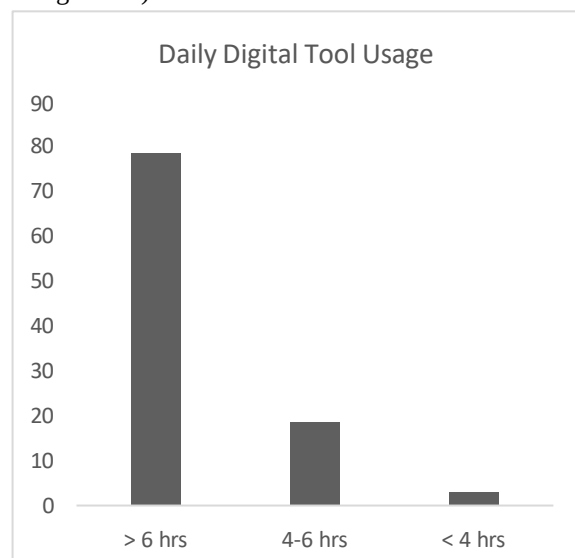


Figure 4. Daily digital tool usage among respondents (showing extensive dependence on digital technologies in graphic design practice).

both advanced software and accessible platforms. It indicates a dual-layered design ecosystem where high-end tools support professional production, while user-friendly platforms enhance speed and accessibility. This extensive daily use of digital tools and their integration into the majority of projects confirm that graphic design practice has transitioned from traditional methods to a fully digital workflow environment. The implication is that digital competence is no longer optional but a core requirement for professional relevance.

Digital media significantly enhances communication effectiveness, with Figure 5 showing improvements in client engagement (87.2%), audience reach (84.7%), and project efficiency, including faster completion rates (89.7%). It also supports creative development, with 82.1% reporting expanded creative possibilities.

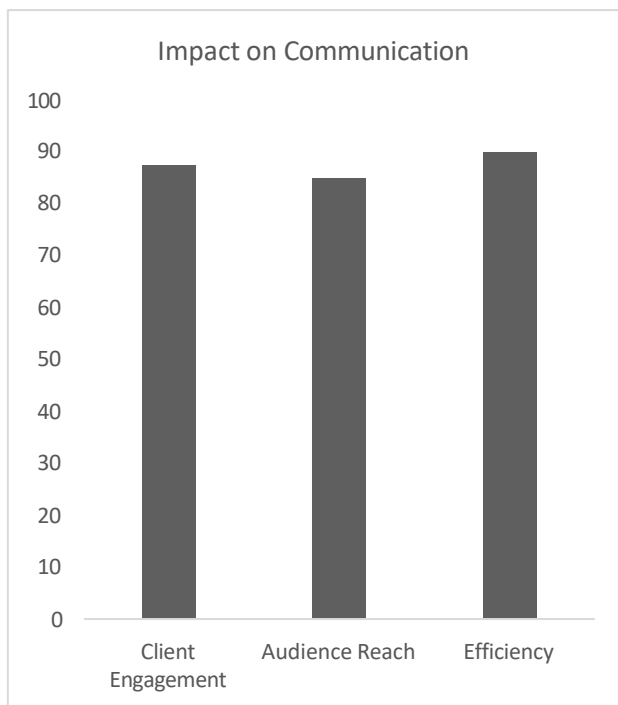


Figure 5. Impact of digital media on communication effectiveness

(showing improvements in engagement, audience reach, and efficiency).

This reveal that digital media significantly enhances the effectiveness of graphic design as a communication tool. Improvements in client engagement, audience reach, and project efficiency suggest that digital platforms enable faster, broader, and more interactive communication. This was supported by qualitative evidence emphasizing

improved speed and engagement: “With social media, you can reach thousands instantly, and clients respond faster than before.” Another informant added: “Motion and digital designs make people understand messages better than static designs.”

Additionally, the expansion of creative possibilities indicates that digital tools are not only functional but also transformative, allowing designers to explore new forms of visual expression. This reinforces the position of graphic designers as strategic communicators rather than mere visual producers.

However, these benefits are constrained by challenges such as poor internet connectivity (76.8%), unstable power supply (68.4%), high software costs (72.3%), and limited access to training (69.5%) as captured in Figure 6.

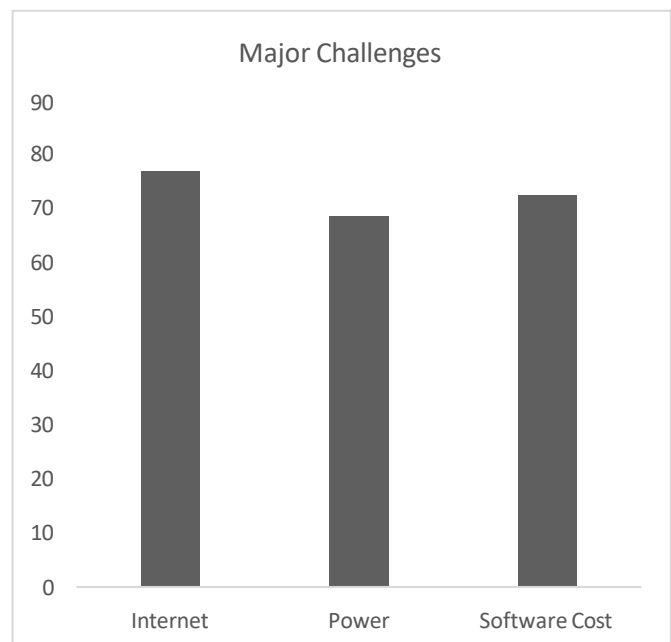


Figure 6. Major challenges affecting digital media adoption among graphic designers (particularly internet connectivity, power supply, and software costs).

Client resistance to digital approaches (63.7%) and market competition (58.4%) further complicate practice. This implies that infrastructure deficits, particularly unreliable internet connectivity and power supply, limit the efficiency and consistency of digital workflows. Financial barriers, including the high cost of software and limited access to training, further restrict the capacity of designers to fully utilize available technologies. While these challenges

were statistically prominent, informants emphasized their practical implications: *“Sometimes you lose hours of work because there is no power or the internet is too slow.”* Similarly, financial constraints were elaborated as limiting professional growth: *“Many designers cannot afford licensed software, so they either use outdated versions or alternatives.”*

Skill gaps were also highlighted as a critical concern: *“There are many new tools, but not everyone has access to proper training to use them effectively.”* These narratives reveal that the challenges are not merely statistical but deeply experiential, affecting productivity, quality, and innovation. Furthermore, client-related issues emerged strongly in qualitative responses, particularly resistance to digital processes: *“Some clients still prefer traditional methods and don’t understand the value of digital design.”* This demonstrates a disconnect between technological advancement and user awareness, which affects the full utilization of digital media. The implication of these challenges is that while digital media adoption is high, it operates within a context of systemic constraints, which may hinder optimal performance and innovation. This highlights the need for improved infrastructure, capacity development, and greater awareness of digital communication value among clients and stakeholders.

Overall, the findings demonstrate that while digital media is deeply integrated into graphic design practice in Benin City, its effectiveness is shaped by both technological opportunities and contextual constraints within a developing economy. These findings align with previous studies by Guanah et al. (2020) and Sujoko et al. (2023) that highlighted the challenges of digital media adoption in developing countries. The results underscore the need for systemic improvements to support digital transformation in the creative industry.

CONCLUSION

This study revealed that digital media has fundamentally transformed graphic design practice in Benin City, positioning designers as key contributors to mass communication. The widespread adoption of digital tools has enhanced communication effectiveness, expanded creative possibilities, and improved professional efficiency. However, the full potential of digital media cannot be realized without addressing the underlying challenges affecting its adoption such as infrastructure

limitations, high costs of acquiring original software applications, and skill gaps which continue to hinder progress. Addressing these issues require coordinated efforts from government, educational institutions, and industry stakeholders.

RECOMMENDATIONS

Based on the findings of the study, the following recommendations are proposed:

1. Government and private stakeholders should invest in digital infrastructure, particularly stable internet connectivity and electricity supply, to enhance the effective utilization of digital media tools among graphic designers. This will support the broader integration of digital technologies in communication practice.
2. Professional bodies, institutions, and training centers should develop continuous digital skill acquisition programmes to improve designers’ proficiency in emerging software and communication technologies. This will address the identified skill gaps affecting effective digital media adoption.
3. Policies and support mechanisms should be introduced to improve access to professional design software and digital resources, particularly for freelancers and early-career practitioners. This could include subsidies, institutional licensing schemes, or affordable subscription models.
4. Greater collaboration between academia, industry, and professional design communities should be encouraged to promote innovation, practical knowledge exchange, and the adaptation of digital media practices to local communication needs and realities.
5. Graphic designers should be encouraged to adopt more strategic and audience-centered digital communication practices in order to maximize client engagement, audience reach, and overall communication effectiveness.

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NEWSPAPER FRAMING OF INSECURITY AND ITS INFLUENCE ON PUBLIC PERCEPTION IN BIDA TOWN

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ABSTRACT

Insecurity in Nigeria, particularly in Northern Nigeria, is increasingly experienced not only as a physical reality but also as a mediated construct shaped by mass media narratives. This study examines newspaper framing of insecurity and its influence on public perception and fear among residents of Bida, Niger State. Grounded in Framing Theory and Cultivation Theory, the study adopts a convergent parallel mixed-methods design, integrating survey data from 378 respondents with content analysis of 25 purposively selected online news articles. Survey results indicate high newspaper exposure significantly shapes cognitive perception of insecurity ($\chi^2(9, N = 378) = 52.31, p < .001$). However, regression analysis shows that perception does not significantly predict fear ($R^2 = 0.002, p = 0.393$), suggesting that emotional responses are contextually mediated. The study concludes that while media framing strongly constructs perceptions of insecurity, fear responses are moderated by lived experience and environmental familiarity. It contributes empirical evidence from a semi-urban Northern Nigerian context, advancing understanding of how mediated insecurity narratives influence public interpretation and emotional resilience.

Keywords: Fear, Insecurity, Media framing, Newspaper, Public perception

INTRODUCTION

Insecurity remains a persistent socio-political challenge in Nigeria, particularly in the North, where banditry, kidnapping, terrorism, and communal violence are widespread. Beyond its physical consequences, insecurity is increasingly mediated through continuous exposure to reports on television, radio, newspapers, and online platforms (Ijirshar et al., 2025). The media shape perceptions of insecurity by selecting, emphasizing, and framing events. Sensationalism, episodic reporting, and conflict-oriented narratives can heighten anxiety and perceived risk (Onwe et al., 2024; Sholola et al., 2025). Digital and social media further expand access to information while facilitating emotionally charged and unverified content, influencing audience fear and risk perception (Ajaegbu et al., 2025).

Insecurity in Northern Nigeria, including banditry, kidnapping, insurgency, and communal conflicts remains a persistent socio-political challenge affecting physical safety and psychological well-being (Ijirshar et al., 2025). Media reporting can heighten perceived insecurity beyond direct exposure, generating fear through mediated experiences (Imam, Ajetunmobi, & Salman, 2022). Media framing shapes how audiences interpret insecurity by emphasizing particular aspects of violent events (Entman, 1993). Nigerian studies indicate that conflict-driven, episodic, and sensational reporting

can amplify perceived threats (Onwe et al., 2024). Digital platforms further intensify these effects through algorithmic amplification. Consequently, media exposure significantly influences public perception, anxiety, and perceived vulnerability (Ajaegbu et al., 2025).

Empirical studies show a strong relationship between media framing and public perceptions of insecurity. Ajaegbu et al. (2025) found that television news framing significantly influences Nigerian audiences' perceptions, while Onwe et al. (2024) reported that political and crisis-oriented newspaper frames shape interpretations of insecurity. Felix, Jigem, and Ngantem (2023) similarly found that online framing influences public understanding. In West Africa, Abwami and Shahid (2024) linked media framing to public opinion and policy responses. Sholola et al. (2025) associated conflict framing with increased threat perception. However, Ijirshar et al. (2025) noted desensitization, while socioeconomic conditions, experiences, and media trust mediate emotional responses.

This study is grounded in Framing and Cultivation Theories. Framing Theory, developed by Entman (1993), explains how media shape reality by selecting and emphasizing particular aspects of events (Asemah, Nwammuo, & Nkwam-Uwaona, 2017). In reporting

insecurity, framing can present violence as political failure, criminality, or systemic instability. Nigerian studies support this view, showing that ownership, political affiliation, and framing influence audience perceptions of insecurity (Onwe et al., 2024; Ajaegbu et al., 2025). However, framing effects may be stronger on cognitive perceptions than emotional fear (Lecheler et al., 2015; Scheufele, 2014).

Cultivation Theory, developed by Gerbner (1969), proposes that prolonged media exposure shapes perceptions of reality. Repeated exposure to insecurity may increase perceived danger or produce a “mean world” perception. Nigerian evidence shows increased insecurity awareness, although fear may be moderated by experience and resilience (Imam et al., 2022; Ijirshar et al., 2025). Together, the theories explain how media construct and sustain perceptions of insecurity.

Although the literature on insecurity in Nigeria is expanding, there has been little incorporation of media content analysis and audience perception research especially on a local level. This void restricts knowledge of the transformation of media framing into social understanding and affect.

Looking into the problem statement, Nigeria, particularly the Northern region, faces persistent insecurity, including banditry, kidnapping, terrorism, and communal violence. Newspapers significantly shape public understanding of these issues, yet reports are often sensational, conflict-oriented, episodic, and fear-inducing (Onwe et al., 2024; Sholola et al., 2025). Despite this influence, limited empirical evidence exists on how newspaper framing affects public perception and emotional fear, especially in semi-urban communities. Previous studies largely examine media content or audience perception separately and focus on major urban centers.

This study therefore investigates newspaper framing of insecurity and its influence on public perception and fear among Bida metropolis residents using a mixed-methods approach. The study is guided by these objectives: to examine the extent to which exposure to media coverage of insecurity influences Bida residents’ perception of insecurity; to assess how exposure to different media platforms influences residents’ fear of insecurity in Bida;

to identify the dominant frame used in the coverage of insecurity in selected Nigerian media; and to determine the tone and sources of insecurity reports in selected media and how they may shape narratives about insecurity.

METHODOLOGY

This study adopted a convergent parallel mixed-methods design, where quantitative survey and content analysis were conducted independently and integrated during interpretation to enable triangulation of media framing patterns and audience responses.

The study was carried out in Bida, Niger State, Nigeria, a semi-urban community with high exposure to national and regional media coverage of insecurity. The population comprised adult residents regularly exposed to media content through television, radio, newspapers, and online platforms.

A sample size of 378 respondents was determined using Cochran’s formula at 95% confidence level and 5% margin of error ($p = 0.5$). A multistage sampling technique was used, Bida was stratified into 14 political wards; thereafter, selected wards were randomly chosen through simple random sampling. In the selected wards, households were systematically selected using a sampling interval, while one eligible respondent aged 18 years and above was purposively selected from each household based on regular exposure to newspaper and online insecurity reports.

Data were collected using a structured questionnaire covering demographics, media exposure, perception, and fear of insecurity, measured on a 4-point Likert scale.

For the content analysis, coding sheet/content category was used. The unit of analysis was the individual news story (headline). Content categories included type of insecurity, dominant frame (fear, conflict, responsibility, human interest), tone, story format, and source type. A total of 25 purposively selected online news reports were analyzed within a defined timeframe.

Reliability of the questionnaire was confirmed using Cronbach’s Alpha (> 0.70). For content analysis, inter-coder reliability was used. Descriptive statistics were used to summarize demographic and response data,

while chi-square and simple linear regression analyses were employed to test relationships between media exposure, perception of insecurity, and fear responses at 0.05 level of significance. Effect sizes (e.g., Cramer's V) were reported where appropriate. Content data were analyzed using frequency and percentage distributions to identify dominant framing patterns. Ethical standards were observed, including informed consent, voluntary participation, confidentiality, and anonymization of respondents. All data were used strictly for academic purposes.

RESULTS AND DISCUSSION

This section presents integrated findings from survey and content analysis using a convergent parallel approach. Survey data from 378 respondents were analyzed using descriptive statistics, chi-square, and regression analysis, while content analysis involved 25 purposively selected online news articles on insecurity were also analysed in frequency and percentage.

Table 1: Demographic Profile of Respondents

Variable	Frequency	Percentage (%)
Gender		
Male	185	48.9
Female	176	46.6
No Response	17	4.5
Age Distribution		
18–25 years	131	34.7
26–35 years	118	31.2
36–45 years	74	19.6
46 years and above	55	14.5

The demographic findings in Table 1 revealed relatively balanced gender participation, with males constituting 48.9% and females 46.6% of respondents. The majority of respondents were youths aged 18–25 years (34.7%), followed by those aged 26–35 years (31.2%), indicating high youth exposure to insecurity-related media content within Bida town.

Table 2: Respondents' Perception of Newspaper Influence on Insecurity Using 4-Point Likert Scale

Statement	Strongly Agree (%)	Agree (%)	Disagree (%)	Strongly Disagree (%)
Newspaper reports influence my perception of insecurity	42	42	10	6
Newspaper reports amplify perceived insecurity severity	39	42	12	7
Frequent exposure to insecurity news increases public concern	45	41	8	6
Newspaper framing affects how people interpret insecurity issues	40	43	11	6

The results Table 2 showed that there was high newspaper exposure related to insecurities among the respondents. In particular, 84% of the respondents strongly agreed or agreed that newspaper reports affect their perception of insecurity, and 81% of respondents strongly agreed or agreed that newspaper reports increase the perceived insecurities. Likewise, 86%

agreed that the constant exposure to insecurity news duly raises communal concerns; 83% confirmed that framing of insecurity issues by the newspaper would impact on how concerns on insecurity would be interpreted. The results indicate that the use of framed insecurity narratives does have a significant impact on people's knowledge and perceptions of insecurity in Bida town.

Table 3: Chi-Square Analysis Showing Relationship Between Newspaper Exposure and Perception of Insecurity

Variable	χ^2	df	p-value	Decision
Newspaper Exposure and Perception of Insecurity	52.31	9	< .001	Significant

The chi-square result in Table 3 shows a statistically significant relationship between media exposure and

perception of insecurity among respondents ($\chi^2 = 52.31$, $df = 9$, $p < .001$). This implies that increased exposure to

insecurity-related media reports significantly influences

how residents perceive insecurity issues within Bida.

Table 4: Simple Linear Regression Analysis on Perception and Fear of Insecurity

Predictor Variable	R ²	Beta (β)	p-value	Decision
Perception of Insecurity Predicting Fear	0.002	0.041	0.393	Not Significant

The regression analysis in Table 4 indicates that perception of insecurity does not significantly predict emotional fear among respondents ($\beta = 0.041$, $p = 0.393$). The R^2 value of 0.002 further suggests that perception explains only 0.2% variation in fear responses, indicating very weak explanatory power.

Table 5: Content Analysis of Newspaper Framing of Insecurity

Variable	Frequency	Percentage (%)
Type of Insecurity Reported		
Banditry	10	40
Kidnapping	7	28
Terrorism	5	20
Communal Conflict	3	12
Dominant Frame		
Fear Frame	12	48
Conflict Frame	5	20
Responsibility Frame	4	16
Human Interest Frame	4	16
Tone of Report		
Negative	17	68
Neutral	5	20
Positive	3	12
Headline Style		
Alarmist	16	64
Moderate	9	36
Story Format		
Straight News	17	68
Feature/Analysis	8	32
Primary Sources Used		
Security Agencies	9	36
Victims	7	28
Government Officials	5	20
Experts/Others	4	16

The content analysis in Table 5 reveals that banditry (40%) and kidnapping (28%) dominated newspaper reports on insecurity in Bida. Fear framing constituted 48% of the reports, while 68% adopted negative tones

and 64% used alarmist headlines. Furthermore, straight news reporting accounted for 68%, with security agencies (36%) serving as the major information sources. These findings indicate that newspaper coverage largely emphasized crisis narratives and episodic reporting patterns with limited focus on contextual or solution-oriented perspectives.

In convergent integration and discussion of findings, the integrated findings from the survey and content analysis reveal a strong convergence between newspaper framing patterns and public perception of insecurity among residents of Bida town. The content analysis showed that newspaper coverage was predominantly fear-driven and episodic, as fear framing accounted for 48% of reports, while 68% adopted negative tones and 64% used alarmist headlines. These findings indicate that insecurity reports were largely presented through crisis-oriented narratives capable of amplifying public concern and perceived threats. This aligns with Framing Theory advanced by Entman in 1993, which explains that the media shape audience interpretation of reality through selection, emphasis, and presentation of issues. The findings further corroborate the empirical studies of Lecheler, Bos, and Vliegenthart (2015), who found that emotionally framed news stories significantly influence audience cognitive interpretation of social issues.

Similarly, the survey findings showed that 84% of respondents agreed that newspaper reports influence their perception of insecurity, while 81% believed that newspaper reports amplify the perceived severity of insecurity. In addition, the chi-square result established a statistically significant relationship between newspaper exposure and perception of insecurity ($\chi^2 = 52.31$, $df = 9$, $p < .001$). These findings support Cultivation Theory developed by Gerbner in 1980, which posits that repeated media exposure shapes audience perception of social reality. The findings also agree with Romer, Jamieson, and Aday (2013), who established that persistent exposure to violence-related news cultivates heightened perceptions of societal danger and insecurity.

However, despite the strong relationship between newspaper exposure and perception, the regression analysis revealed that perception of insecurity did not significantly predict emotional fear among respondents ($\beta = 0.041$, $p = 0.393$). This finding partially contradicts the deterministic assumptions of Cultivation Theory which suggest that repeated exposure to violent media content directly increases fear. Instead, the result supports the argument of Slone (2020) that individuals living in insecurity-prone environments often develop psychological adaptation and coping mechanisms that moderate emotional fear responses. Similarly, Nabi and Sullivan (2021) argued that audience emotional reactions to media content are mediated by personal experiences and contextual realities rather than exposure alone.

Furthermore, the predominance of negative and alarmist reporting patterns observed in this study aligns with the findings of Gross and D'Ambrosio (2014), who maintained that emotionally charged media framing intensifies perceived vulnerability and social anxiety among audiences. The dominance of straight news reporting and reliance on security agencies as primary sources also confirms the argument of Iyengar (2021) that episodic reporting limits contextual understanding and encourages issue interpretation through isolated crisis events rather than broader structural explanations.

Overall, the integrated findings demonstrate a qualified convergence between newspaper framing and public perception of insecurity. While newspaper framing strongly shapes cognitive understanding and interpretation of insecurity issues, emotional fear responses remain context-dependent, psychologically adaptive, and socially mediated.

CONCLUSION

This study concludes that media framing significantly influences public perception of insecurity in Bida metropolis. The findings revealed that continuous exposure to insecurity-related media content, particularly fear-based and conflict-oriented reports, contributes to heightened cognitive perception of insecurity among residents. The dominance of negative tones, alarmist headlines, and episodic reporting patterns in the analysed media contents demonstrates that Nigerian media largely

construct insecurity narratives in ways that amplify perceived societal risk.

However, the study also established that although media exposure significantly shapes perception, it does not directly predict emotional fear among audiences. This suggests that emotional reactions to insecurity are moderated by realities such as lived experiences, environmental familiarity, coping mechanisms, and psychological resilience. Consequently, the study concludes that media effects on insecurity are not entirely deterministic but operate through complex interactions between media narratives and social realities. The study therefore contributes to media effects scholarship by extending the assumptions of Framing and Cultivation theories within the context of insecurity reporting in Northern Nigeria. It further fills an empirical gap by providing integrated evidence from both media content analysis and audience perception within a semi-urban Nigerian setting.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are made:

1. Media organisations should adopt more balanced, contextual, and solution-oriented approaches in reporting insecurity issues in order to minimise unnecessary fear amplification among audiences.
2. Journalists and editors should reduce excessive use of sensational headlines, fear-inducing language, and conflict-driven framing that may heighten public anxiety and social tension.
3. Media practitioners should incorporate expert analysis, peace journalism strategies, and explanatory reporting into insecurity coverage to provide audiences with deeper understanding rather than mere crisis amplification.
4. It is recommended that future studies should further investigate insecurity reporting within semi-urban and rural communities in Northern Nigeria in order to deepen empirical understanding of how mediated insecurity narratives shape public interpretation, psychological adaptation, and emotional resilience across different socio-cultural issues.

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ELECTORAL VIOLENCE AND DEMOCRATIC CONSOLIDATION: AN ANALYSIS OF THE POST-ELECTION CRISES IN NIGERIA'S FOURTH REPUBLIC

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ABSTRACT

This study examined electoral violence and democratic consolidation in Nigeria's Fourth Republic, with particular emphasis on the post-election crises that have characterized the country's democratic experience since 1999. Specifically, the study investigated the causes of electoral violence, assessed its implications for democratic consolidation, and evaluated the effectiveness of electoral reforms and conflict management mechanisms in mitigating post-election crises. A qualitative research design was adopted, relying exclusively on secondary data obtained from peer-reviewed journal articles, books, election reports, policy documents, newspaper publications, and reports of the Independent National Electoral Commission (INEC), civil society organizations, and international development agencies. Data were analyzed using thematic content analysis. The findings revealed that weak electoral institutions, political elite manipulation, poverty, unemployment, ethnic and religious divisions, and ineffective security management constitute the major drivers of electoral violence in Nigeria. The study further established that electoral violence undermines democratic consolidation by eroding public confidence in democratic institutions, discouraging political participation, weakening electoral credibility, and fostering political instability. Although recent electoral reforms, including the introduction of electronic voter accreditation and the electronic transmission of election results, have enhanced electoral transparency, their effectiveness has been constrained by implementation challenges, political interference, and institutional weaknesses. The study concludes that sustainable democratic consolidation in Nigeria depends on credible elections, strong and independent electoral institutions, impartial security agencies, adherence to the rule of law, and inclusive governance. It recommends strengthening the autonomy of electoral institutions, prosecuting electoral offenders, promoting youth empowerment and civic education, enhancing voter education programmes, and implementing sustained democratic and governance reforms. The study contributes to the growing body of literature on electoral violence and democratic governance by highlighting the institutional reforms necessary for promoting peaceful elections and democratic stability in Nigeria.

Keywords: Electoral Violence, Democratic Consolidation, Post-Election Crises, Electoral Reforms, Political Stability, Nigeria's Fourth Republic.

INTRODUCTION

Electoral violence has continued to constitute a major obstacle to democratic consolidation in Nigeria's Fourth Republic. Since the restoration of democratic governance in 1999, elections in Nigeria have frequently been accompanied by violence, intimidation, political assassinations, destruction of property, and post-election conflicts that threaten political stability and national cohesion. Rather than functioning as peaceful mechanisms for political participation and leadership recruitment, elections have increasingly become highly contested struggles for state power and access to public resources. This situation has weakened public trust in democratic institutions and undermined the legitimacy of electoral outcomes in the country (Ameh-Ogogo, 2024). Democratic consolidation refers to the process through which democratic institutions, values, and practices become stable, institutionalized, and widely accepted within a

political system. A consolidated democracy is characterized by credible elections, rule of law, political tolerance, citizen participation, and peaceful transfer of power. However, the persistence of electoral violence in Nigeria has significantly hindered the consolidation of democracy by creating fear, reducing voter participation, and promoting political instability (Tai *et al.*, 2024). Electoral violence weakens electoral credibility and often leads to post-election disputes that challenge the legitimacy of elected governments.

Nigeria's Fourth Republic has witnessed several episodes of post-election crises that exposed the fragility of democratic institutions. The 2003 and 2007 general elections were widely criticized for electoral irregularities, political intimidation, and violent clashes among party supporters (Salihu and Mohammed, 2024). Similarly, the 2011 post-election violence, particularly in Northern

Nigeria, resulted in hundreds of deaths, displacement of persons, and destruction of public and private property following disputes over presidential election results (Ameh-Ogogo, 2024). The 2023 general elections also witnessed allegations of voter suppression, vote-buying, electoral manipulation, attacks on electoral officials, and violence in several states, thereby raising concerns regarding the credibility and transparency of the electoral process in Nigeria (Oni et al., 2025). Recent scholarly studies attributed electoral violence in Nigeria to multiple structural and institutional factors. These include weak electoral institutions, poverty, unemployment, ethnic and religious divisions, proliferation of small arms, political intolerance, corruption, and the desperation of political elites to capture political power at all costs (Mbanusi & Osuagwu, 2025). The winner-takes-all nature of Nigerian politics intensifies political competition and encourages politicians to mobilize thugs, manipulate electoral processes, and exploit ethnic or regional sentiments to secure electoral advantage. In many cases, political actors perceive electoral defeat as political and economic exclusion, thereby increasing the likelihood of violent reactions to election outcomes.

Furthermore, the role of political parties and electoral management institutions remains central to understanding electoral violence in Nigeria. Weak internal party democracy, candidate imposition, and lack of transparent party primaries often generate grievances among political actors and supporters, which later escalate into electoral disputes and violence. Allegations of electoral fraud and lack of confidence in the Independent National Electoral Commission have also contributed to recurring post-election crises in the country. Although electoral reforms such as the introduction of the Bimodal Voter Accreditation System (BVAS) and electronic transmission of results were intended to improve electoral credibility, challenges relating to implementation, logistics, and political interference continue to undermine electoral integrity (Ebajemito, 2025). The persistence of electoral violence has serious implications for democratic consolidation in Nigeria. Electoral conflicts discourage political participation, reduce voter confidence, weaken democratic legitimacy, and threaten national security (Mbanusi & Osuagwu, 2025). Insecurity during elections also undermines democratic accountability by limiting citizens' ability to freely choose political leaders. Recent studies further indicate that electoral violence contributes

to state fragility, institutional distrust, and declining public confidence in democratic governance (Oni et al., 2025). In addition, the continuous recurrence of post-election violence reinforces political instability and weakens the institutional foundations necessary for democratic sustainability in Nigeria. Effectiveness of these reforms (Ebajemito, 2025). As a result, electoral violence discourages political participation, weakens democratic legitimacy, reduces citizens' confidence in governance, and threatens national security and sustainable democratic development (Oni et al., 2025). Although previous studies have examined electoral violence in Nigeria, much of the existing literature focuses on specific elections, immediate causes of electoral conflict, or electoral reforms in isolation. Relatively few studies have critically examined how recurring post-election crises have collectively affected democratic consolidation throughout Nigeria's Fourth Republic. This study seeks to fill this gap by providing a comprehensive analysis of the relationship between electoral violence and democratic consolidation, with particular emphasis on post-election crises since 1999.

Against this background, the study examines the causes, manifestations, and implications of post-election violence for democratic consolidation in Nigeria's Fourth Republic. It further evaluates the effectiveness of electoral reforms and conflict management mechanisms while proposing policy measures capable of strengthening electoral credibility, reducing political violence, and promoting sustainable democratic governance in Nigeria.

Concept of Electoral Violence: Electoral violence refers to the use of force, intimidation, coercion, harassment, or physical attacks before, during, and after elections in order to influence electoral outcomes or undermine political participation (Adebayo and Omotola (2024). Electoral violence may be perpetrated by political actors, party supporters, security agencies, or other non-state actors seeking political advantage through unlawful means. In democratic societies, elections are expected to provide peaceful avenues for political competition and leadership recruitment; however, in many developing democracies such as Nigeria, electoral processes are frequently characterized by violence and instability (Nwokora & Pelizzo, 2023). Recent studies argue that electoral violence in Nigeria has become institutionalized within the political process due to weak democratic institutions, political

intolerance, poverty, and elite manipulation of electoral systems. According to Adebayo and Omotola (2024), electoral violence in Nigeria manifests in various forms including voter intimidation, ballot box snatching, assassination of political opponents, destruction of electoral materials, and post-election protests. These violent activities often undermine electoral credibility and reduce citizens' trust in democratic governance. Scholars further maintain that electoral violence in Nigeria is deeply connected to the high economic and political value attached to public office. Political power in Nigeria is often associated with access to state resources, patronage networks, and economic opportunities, thereby making elections highly competitive and conflict-ridden (Okeke & Eme, 2023). Consequently, political actors frequently mobilize youths and criminal groups to intimidate opponents and manipulate electoral outcomes.

Democratic Consolidation in Nigeria: Democratic consolidation refers to the process whereby democratic institutions, norms, and practices become stable, legitimate, and deeply rooted within a political system. A consolidated democracy is characterized by regular credible elections, respect for rule of law, institutional accountability, political participation, and peaceful transfer of power (Huntington, 1991). In Nigeria, democratic consolidation has remained a major challenge despite over two decades of uninterrupted civilian rule since 1999. Recent literature indicates that democratic consolidation in Nigeria remains fragile due to persistent electoral violence, corruption, weak institutions, insecurity, and governance failures. According to Yusuf and Abdullahi (2024), the inability of electoral institutions to conduct transparent and violence-free elections continues to weaken democratic legitimacy in Nigeria's Fourth Republic. The recurring post-election crises in several states reveal the vulnerability of democratic structures and the inability of state institutions to effectively manage electoral disputes. Similarly, Adeosun (2023) argues that democratic consolidation in Nigeria is undermined by weak political culture, ethnic politics, and political exclusion. The study notes that many citizens perceive elections as predetermined processes manipulated by political elites, thereby reducing political trust and civic participation. In addition, the politicization of security agencies and selective enforcement of electoral laws further weaken democratic accountability and institutional credibility.

Electoral Violence in Nigeria's Fourth Republic: Nigeria's Fourth Republic has experienced multiple cases of electoral violence since 1999. The 2003 and 2007 general elections were widely criticized for electoral fraud, intimidation, and violent clashes among party supporters. However, the 2011 post-election violence is considered one of the deadliest electoral crises in Nigeria's democratic history. The violence erupted following the announcement of presidential election results and resulted in widespread killings, displacement, and destruction of property across northern Nigeria (International Crisis Group, 2023). Studies reveal that electoral violence has persisted despite several electoral reforms introduced by the government and the Independent National Electoral Commission. The 2023 general elections witnessed incidents of voter suppression, attacks on electoral officials, destruction of polling units, and intimidation of voters in states such as Lagos, Rivers, Kano, and Imo (Ojo & Ibrahim, 2025). These developments demonstrate that electoral violence remains a recurring feature of Nigeria's democratic process. According to Salihu and Mohammed (2024), the increasing use of technology in elections, including the Bimodal Voter Accreditation System (BVAS), has improved electoral transparency to some extent but has not completely eliminated political violence. Political actors continue to exploit ethnic and religious divisions, spread misinformation, and mobilize supporters for violent confrontation during elections.

Causes of Post-Election Crisis in Nigeria: Several scholars have identified structural and institutional factors responsible for post-election crises in Nigeria. One major factor is weak electoral institutions. When electoral bodies are perceived as biased or ineffective, political actors and citizens often reject election outcomes, leading to protests and violence (Akinola & Lawal, 2023). Allegations of results manipulation, vote-buying, and electoral irregularities frequently trigger post-election conflicts. Another major cause is poverty and youth unemployment. Recent studies indicate that unemployed youths are often recruited by politicians as political thugs to intimidate opponents and disrupt elections. According to Ibrahim and Musa (2024), economic hardship and social exclusion make young people vulnerable to political manipulation and mobilization for violence during elections. Ethnic and religious politics also contribute significantly to electoral violence in Nigeria. Political competition in Nigeria is often framed along ethnic and religious lines, thereby

increasing tensions among communities during elections. In many cases, election outcomes are interpreted as victories or defeats for particular ethnic or religious groups, which heightens the risk of violence (Ezeani & Nnoli, 2023). Furthermore, weak security response and impunity have encouraged recurring electoral violence. Political actors involved in electoral crimes are rarely prosecuted, creating a culture of impunity that leads to future violence. Scholars argue that the absence of accountability for electoral offenders undermines electoral justice and weakens democratic consolidation (Usman & Chukwuemeka, 2024).

Electoral Violence and Democratic Consolidation: The relationship between electoral violence and democratic consolidation has attracted considerable scholarly attention in recent years. Studies consistently show that persistent electoral violence weakens democratic institutions, reduces political participation, and undermines public trust in governance. According to Obi and Nwachukwu (2025), democratic consolidation cannot be achieved where elections are characterized by fear, intimidation, and political instability. Electoral violence discourages voter turnout and civic engagement because citizens become fearful of participating in political activities. This weakens democratic legitimacy and limits political inclusion. In addition, post-election violence often results in destruction of infrastructure, displacement of citizens, and increased insecurity, thereby diverting state resources away from development initiatives (Adeosun, 2023). Recent literature further emphasizes that democratic consolidation requires credible electoral processes, institutional independence, political tolerance, and effective conflict management mechanisms. Where electoral violence persists, democratic institutions become fragile and vulnerable to authoritarian tendencies (Nwankwo & Alabi, 2024). Consequently, addressing electoral violence remains essential for strengthening democratic governance and political stability in Nigeria.

Theoretical Framework

Frustration–Aggression Theory: This study is anchored on the Frustration–Aggression Theory, which explains how frustration arising from blocked expectations, perceived injustice, or denial of opportunities can lead individuals or groups to engage in aggressive and violent behaviour. The theory was originally developed by John Dollard, Leonard Doob, Neal Miller, O. H. Mowrer, and

Robert Sears in 1939. The theory was later expanded by Ted Robert Gurr through the concept of relative deprivation, which argues that political violence often emerges when people perceive a gap between their expectations and actual socio-political realities (Gurr, 1970). The central proposition of the theory is that frustration generated by the inability to achieve desired goals often produces aggressive responses. In political contexts, when citizens perceive elections as manipulated, unfair, or exclusionary, frustration may result in protests, riots, destruction of property, and post-election violence. The theory therefore provides an important explanation for electoral violence and democratic instability in emerging democracies such as Nigeria.

Major Assumptions of the Theory: The Frustration–Aggression Theory is based on several key assumptions:

1. Frustration leads to aggression: The theory assumes that individuals or groups who are denied expected political, economic, or social outcomes may resort to violent behaviour.
2. Perceived injustice triggers violence: Aggression is more likely to occur when people perceive political processes as unfair, manipulated, or oppressive.
3. Violence is a reaction to blocked aspirations: Where democratic expectations such as free and fair elections are frustrated, political violence becomes a possible response.
4. Relative deprivation encourages conflict: The theory assumes that inequality, exclusion, and marginalization increase frustration and create conditions for violent political reactions.
5. Political competition intensifies aggression: In highly competitive political environments, frustration among losing political actors and supporters may escalate into post-election violence.

Criticisms of the Theory: Despite its relevance, the Frustration–Aggression Theory has been criticized by several scholars.

1. Overgeneralization: Critics argue that not all frustrated individuals or groups engage in violence, as some may adopt peaceful or legal means of expressing grievances.
2. Neglect of Structural Factors: The theory focuses mainly on psychological reactions while giving limited attention to structural issues such as ethnicity, elite manipulation, weak institutions, and political culture.

3. Inability to Explain Organized Political Violence: Some scholars argue that electoral violence in Nigeria is often strategically organized by political elites rather than spontaneous reactions to frustration.

Relevance of the Theory to Democratic Consolidation in Nigeria: The Frustration–Aggression Theory remains useful in explaining the recurring nature of post-election violence in Nigeria’s Fourth Republic. The theory highlights how electoral injustice, poor governance, unemployment, and political exclusion create frustrations that threaten democratic stability. It further explains why electoral violence persists despite electoral reforms and democratic transitions. By applying this theory, the study demonstrates that democratic consolidation in Nigeria cannot be achieved without credible elections, institutional transparency, political inclusion, and effective conflict resolution mechanisms. Addressing the root causes of frustration among citizens and political actors is therefore essential for reducing electoral violence and strengthening democracy in Nigeria.

Application of the Theory to the Study: The Frustration–Aggression Theory is highly relevant to the study of electoral violence and democratic consolidation in Nigeria’s Fourth Republic. Electoral violence in Nigeria often emerges from frustrations associated with disputed election results, electoral fraud, political exclusion, and perceived manipulation of democratic institutions. In many elections within Nigeria’s Fourth Republic, supporters of political parties who believed that electoral outcomes did not reflect the will of the people reacted violently against the state, electoral institutions, and opposing political groups. For example, the post-election violence following the 2011 general elections was largely linked to frustration among groups who perceived the presidential election outcome as unjust and manipulated (International Crisis Group, 2023). The theory also explains how unemployment, poverty, and political marginalization make youths vulnerable to mobilization for electoral violence. Frustrated youths who experience economic hardship are often recruited by political elites as thugs during elections. Similarly, weak electoral institutions and lack of accountability for electoral offences contribute to public frustration and declining trust in democracy. In relation to democratic consolidation, the theory demonstrates that where elections consistently generate frustration and violence, democratic institutions become

weak and unstable. Electoral violence discourages political participation, reduces citizens’ confidence in governance, and undermines democratic legitimacy. Therefore, sustainable democratic consolidation in Nigeria depends on credible elections, transparent electoral processes, and effective management of political grievances.

METHODOLOGY

This study adopted a qualitative research design based exclusively on documentary analysis to examine the relationship between electoral violence and democratic consolidation in Nigeria’s Fourth Republic. The qualitative approach was considered appropriate because it facilitates an in-depth understanding and interpretation of complex political phenomena, electoral conflicts, and democratic processes that cannot be adequately explained using quantitative methods. It also enables the researcher to synthesize evidence from diverse documentary sources to provide a comprehensive analysis of the subject under investigation. The study relied entirely on secondary data obtained from credible academic and institutional sources. These included peer-reviewed journal articles, textbooks, government publications, electoral reports, policy documents, newspaper publications, reports of the Independent National Electoral Commission (INEC), publications of civil society organizations, and reports produced by international organizations such as the United Nations Development Programme (UNDP), the International Crisis Group (ICG), the European Union Election Observation Mission (EU-EOM), and other relevant institutions. Additional scholarly materials were retrieved from reputable electronic databases, including Google Scholar, JSTOR, Scopus, and ResearchGate.

Documents were selected based on their relevance to the objectives of the study, publication credibility, methodological quality, and coverage of electoral violence and democratic governance in Nigeria between 1999 and 2025. Only materials that addressed electoral violence, post-election crises, electoral reforms, democratic governance, and democratic consolidation within the Nigerian context were included in the analysis. Data were analyzed using content analysis. The analytical process involved four stages: identification of relevant documents; careful reading and coding of textual information; categorization of recurring themes; and interpretation of the findings in relation to the objectives of the study and existing literature. The major themes that emerged

included the causes of electoral violence, manifestations of post-election crises, implications for democratic consolidation, electoral reforms, and conflict management mechanisms. This analytical procedure enabled the study to identify patterns, relationships, and recurring issues associated with electoral violence in Nigeria's Fourth Republic.

The study covered the period from 1999 to 2025, corresponding with the commencement of Nigeria's Fourth Republic. This period was selected because it captures all democratic election cycles since the country's return to civilian rule and provides sufficient evidence for assessing the persistent nature of post-election violence and its implications for democratic consolidation. To ensure the trustworthiness of the findings, the study adopted source triangulation by comparing information from multiple academic and institutional publications. Credibility was enhanced through the use of peer-reviewed scholarly sources and official reports, while dependability and conformability were achieved by applying a systematic and transparent analytical procedure throughout the study. Ethical standards were maintained through proper acknowledgment of all sources using the APA 7th edition referencing style and by ensuring that the views and findings of original authors were accurately represented.

RESULTS OF THE FINDINGS

The findings of this study were organized thematically based on the research objectives and evidence obtained from secondary sources. The results reveal that electoral violence remains a major obstacle to democratic consolidation in Nigeria's Fourth Republic.

Theme 1: Weak Electoral Institutions and Electoral Violence: The findings revealed that weak electoral institutions significantly contribute to electoral violence in Nigeria. Reports from the Independent National Electoral Commission and election observer missions indicated persistent allegations of electoral malpractice, vote-buying, intimidation, and manipulation of election results across several electoral cycles. The study found that public distrust in electoral management institutions often triggers protests and post-election crises, particularly when election outcomes are perceived as lacking credibility. The findings further showed that delayed justice for electoral offences and weak enforcement of electoral laws encourage political actors to engage in violence without fear of

prosecution. Secondary data reviewed from the 2011, 2015, 2019, and 2023 elections demonstrated that electoral irregularities frequently generated tensions that escalated into violent confrontations among party supporters.

Theme 2: Thuggery and Manipulation by Political Elite: The study found that political elites play a central role in the organization and financing of electoral violence. Evidence from journal articles and policy reports revealed that politicians often recruit unemployed youths as political thugs to intimidate opponents, disrupt campaigns, and manipulate voting processes. The findings showed that poverty and unemployment increase youth vulnerability to political manipulation. In many states, political actors exploited socio-economic hardship to mobilize young people for violent political activities during elections. This pattern was particularly evident in highly competitive elections where access to political office was linked to economic benefits and patronage networks.

Theme 3: Ethnic and Religious Dimensions of Electoral Violence: The results indicated that ethnic and religious divisions remain significant drivers of electoral violence in Nigeria. Secondary sources reviewed revealed that political competition is frequently framed around ethnic and religious identities, thereby intensifying political tensions during elections. The findings showed that election outcomes are often interpreted as victories or defeats for particular ethnic or religious groups. Consequently, post-election violence tends to occur more intensely in politically polarized regions where identity politics strongly influences voter behavior. The 2011 post-election crisis was identified as one of the clearest examples of identity-based electoral violence in Nigeria's Fourth Republic.

Theme 4: Electoral Violence and Democratic Consolidation: The study found that persistent electoral violence negatively affects democratic consolidation in Nigeria. Electoral violence discourages voter participation, weakens citizens' confidence in democratic institutions, and undermines the legitimacy of elected governments. The findings further revealed that repeated post-election crises contribute to political instability, destruction of lives and property, and declining trust in governance. Secondary evidence indicated that fear of violence during elections reduces civic engagement and political participation, especially among women, youths, and vulnerable

populations. Additionally, the study found that electoral violence weakens democratic culture by promoting political intolerance and undermining peaceful political competition. This situation limits the institutionalization of democratic norms and threatens the sustainability of Nigeria's democratic process.

Theme 5: Electoral Reforms and Conflict Management:

The findings revealed that electoral reforms introduced in recent years have produced mixed outcomes. Innovations such as electronic voter accreditation and digital transmission of results improved transparency to some extent; however, implementation challenges, logistical failures, and political interference reduced their effectiveness. The study also found that conflict management mechanisms remain weak. Security agencies were often accused of bias, selective enforcement, and excessive use of force during elections. Furthermore, poor coordination among electoral stakeholders limited the effectiveness of violence prevention strategies. Despite these challenges, the findings indicated that civic education, election monitoring, and increased participation of civil society organizations contributed positively toward reducing electoral tensions in some areas.

DISCUSSION OF FINDINGS

The findings of this study demonstrate that electoral violence remains a significant obstacle to democratic consolidation in Nigeria's Fourth Republic. The analysis revealed that weak electoral institutions, manipulation by political elite, socio-economic inequalities, and ethnic and religious divisions continue to fuel post-election crises and undermine democratic governance. These findings suggest that electoral violence in Nigeria is not merely an election-day phenomenon but a manifestation of deeper structural and institutional weaknesses that have persisted since the country's return to democratic rule in 1999. The finding that weak electoral institutions contribute significantly to electoral violence supports previous studies, including Yusuf and Abdullahi (2024), which argued that ineffective electoral management, inadequate enforcement of electoral laws, and delayed prosecution of electoral offenders undermine public confidence in elections. This finding further reinforces the assumptions of the Frustration–Aggression Theory, which posits that individuals and political actors are more likely to resort to violence when legitimate political expectations are

frustrated. In the Nigerian context, perceptions of electoral fraud, vote manipulation, and judicial delays often generate frustration among political actors and supporters, thereby increasing the likelihood of post-election violence. The implication is that strengthening electoral institutions is fundamental to achieving credible elections and sustainable democratic consolidation.

The study further established that political elites remain central actors in the organization and financing of electoral violence. The findings corroborate those of Okeke and Eme (2023), who observed that politicians frequently exploit poverty, unemployment, and youth vulnerability to recruit political thugs and orchestrate violence before, during, and after elections. This finding highlights the political economy dimension of electoral violence, where competition for political office is driven by the control of state resources rather than public service. Consequently, electoral violence persists because the perceived benefits of political office often outweigh the costs associated with unlawful electoral conduct. Another important finding is the continued influence of ethnic and religious identities on electoral behaviour and post-election conflicts. Consistent with the findings of Ezeani and Nnoli (2023), the study found that identity politics continues to intensify electoral competition, deepen political polarization, and weaken national integration. The exploitation of ethnic and religious sentiments by political actors not only undermines electoral credibility but also threatens peaceful coexistence and democratic stability. This suggests that democratic consolidation in Nigeria requires governance structures and political processes that promote national integration, inclusiveness, and issue-based political competition. The study also found that electoral violence negatively affects democratic consolidation by reducing voter participation, weakening public confidence in democratic institutions, and undermining the legitimacy of elected governments. This finding supports the argument of Nwankwo and Alabi (2024) that democratic consolidation depends on credible elections, institutional accountability, political inclusion, and peaceful political competition. The persistent occurrence of violence during elections discourages citizens from participating in the democratic process and weakens democratic culture, thereby limiting the capacity of democratic institutions to gain legitimacy and public trust. Furthermore, although recent electoral reforms, including the introduction of the Bimodal Voter Accreditation System (BVAS) and

electronic transmission of election results, have improved electoral transparency, the findings indicate that these reforms have not substantially reduced electoral violence because of implementation challenges, political interference, inadequate logistics, and weak institutional capacity. This finding is consistent with Salihu and Mohammed (2024), who argued that technological innovations alone cannot guarantee credible elections without complementary institutional, legal, and governance reforms. The implication is that electoral reform should extend beyond technological innovations to include institutional independence, effective law enforcement, and judicial accountability.

The study equally established that weak conflict management mechanisms contribute to the recurrence of post-election violence in Nigeria. The perceived partisanship of security agencies, coupled with the failure to prosecute perpetrators of electoral offences, reinforces a culture of impunity that encourages future electoral violence. This finding suggests that effective conflict prevention requires impartial security institutions, an independent judiciary, and timely prosecution of electoral offenders to strengthen public confidence in democratic governance.

Overall, the findings demonstrate that electoral violence and democratic consolidation are closely interconnected. Sustainable democratic consolidation in Nigeria cannot be achieved solely through periodic elections but requires strong democratic institutions, effective electoral administration, and inclusive governance, adherence to the rule of law, socio-economic development, and sustained political commitment to electoral integrity. Addressing the structural drivers of electoral violence including poverty, unemployment, political exclusion, identity politics, and institutional weaknesses remains essential for promoting peaceful elections, democratic stability, and long-term political development in Nigeria.

CONCLUSION

This study examined electoral violence and democratic consolidation in Nigeria's Fourth Republic with particular attention to the recurring post-election crises that have characterized the country's democratic experience since 1999. The study established that electoral violence remains one of the greatest threats to democratic stability, political participation, and institutional legitimacy in Nigeria. The

findings revealed that weak electoral institutions, political elite manipulation, poverty, unemployment, ethnic and religious divisions, and ineffective conflict management mechanisms significantly contribute to electoral violence in the country. The study further showed that electoral violence undermines democratic consolidation by reducing citizens' trust in democratic institutions, discouraging voter participation, and weakening the credibility of electoral outcomes. The study also found that although electoral reforms and technological innovations introduced by the Independent National Electoral Commission have improved certain aspects of the electoral process, challenges such as political interference, weak law enforcement, and institutional inefficiency continue to limit their effectiveness. Consequently, democratic consolidation in Nigeria remains fragile due to persistent electoral conflicts and governance deficits. Furthermore, the study concluded that electoral violence in Nigeria is deeply rooted in broader socio-economic and political conditions, including inequality, exclusion, and the struggle for state power and resources. As such, addressing electoral violence requires more than periodic electoral reforms; it demands comprehensive institutional strengthening, good governance, economic inclusion, and credible democratic practices. The study therefore emphasizes that sustainable democratic consolidation in Nigeria depends on transparent and credible elections, independent electoral institutions, impartial security agencies, political accountability, and effective justice systems capable of prosecuting electoral offenders. Without addressing these structural challenges, electoral violence is likely to persist and continue to threaten Nigeria's democratic development. Ultimately, the study concludes that democratic consolidation in Nigeria can only be achieved when elections are conducted peacefully, citizens have confidence in democratic institutions, and political competition is guided by democratic norms rather than violence and coercion.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are proposed to address electoral violence and strengthen democratic consolidation in Nigeria:

1. Inspector-General of Police, the Chief Justice of Nigeria, and Service Chiefs. A transparent and merit-based appointment process would strengthen institutional independence, enhance public

confidence, and improve the credibility of Nigeria's democratic system.

2. **Promote Continuous Electoral Reform:** Electoral reforms should be continuous rather than episodic. Periodic reviews of electoral laws, effective stakeholder engagement, improved election logistics, and wider deployment of appropriate technology should be pursued to address emerging challenges and strengthen public confidence in the electoral process.
3. **Strengthening Electoral Institutions:** The Independent National Electoral Commission should be granted greater institutional independence, adequate funding, and improved operational capacity to conduct free, fair, and credible elections. Electoral laws should also be strictly enforced to reduce electoral malpractice and violence.
4. **Prosecution of Electoral Offenders:** Government and relevant security agencies should ensure the investigation and prosecution of individuals involved in electoral violence, vote-buying, ballot box snatching, and other electoral offences. Ending the culture of impunity will discourage future electoral violence.
5. **Political Party Reforms:** Political parties should promote internal democracy, transparency, and issue-based campaigns rather than ethnic, religious, or violent mobilization. Party leaders should discourage the recruitment of political thugs and adopt peaceful conflict-resolution mechanisms during elections.
6. **Youth Empowerment and Employment Creation:** The government should implement sustainable economic empowerment programmes targeting unemployed youths who are often recruited for electoral violence. Skills acquisition, entrepreneurship support, and job creation initiatives can reduce youth vulnerability to political manipulation.
7. **Civic and Voter Education:** Civil society organizations, educational institutions, and the media should intensify voter education campaigns to promote democratic values, political tolerance, and peaceful participation in elections. Citizens should be educated on the dangers of electoral violence and the importance of democratic engagement.
8. **Strengthening Security Sector Neutrality:** Security agencies should remain professional, impartial, and non-partisan during elections. Adequate training should be provided to security personnel on election

security management, human rights protection, and conflict prevention.

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BUSINESS AND MANAGEMENT

EFFECT OF PRODUCT INNOVATION ON THE PROFITABILITY OF BUSINESS ORGANIZATIONS: A STUDY OF SELECTED PURE WATER COMPANIES IN BIDA METROPOLIS

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ABSTRACT

In today's dynamic and highly competitive market, product innovation has emerged as a vital strategic mechanism for driving firm performance, competitive advantage, and long-term sustainability. This study examines the effect of product innovation on the profitability of business organizations, with a specific focus on selected pure water (sachet water) manufacturing companies in Bida Metropolis, Nigeria. Anchored on Schumpeter's Innovation Theory, the Resource-Based View (RBV), and Dynamic Capabilities Theory, the conceptual framework evaluates how key dimensions of product innovation—such as advanced water treatment technologies, tamper-proof and branded packaging, product diversification, regulatory compliance (e.g., NAFDAC certification), and innovative distribution channels—impact core financial and operational profitability metrics. Synthesizing extant literature and empirical evidence, the study demonstrates a significant positive relationship between product innovation and firm profitability, driven by improved resource utilization, cost efficiency, increased sales volume, and heightened customer trust. However, the findings also highlight critical operational bottlenecks confronting small and medium-scale enterprises (SMEs) in the sector, notably severe financial constraints, high technology adoption costs, weak research and development (R&D) structures, and limited managerial capacity in strategic innovation. The study concludes that continuous product innovation is not merely an operational choice, but an essential strategic capability required for firm survival and profit growth in saturated markets. To overcome key barriers, the study recommends that SME management allocate dedicated financial resources for R&D and technology upgrades, undertake continuous capacity building in innovation management, and embed innovation-driven key performance indicators (KPIs) into financial performance systems. Furthermore, it advocates for targeted government interventions—such as accessible low-interest micro-loans and supportive policy frameworks—to foster sustainable growth across the pure water industry and similar manufacturing sub-sectors.

Keywords: Product Innovation, Profitability, Pure Water Industry, SMEs, Bida Metropolis, Resource-Based View, Competitive Advantage.

INTRODUCTION

In today's highly competitive and dynamic business environment, product innovation has emerged as a critical strategic tool for enhancing the profitability and long-term survival of business organizations. This is particularly relevant for small and medium-scale enterprises operating in developing economies such as: Nigeria, where intense competition, price sensitivity, and environmental challenges significantly influence business outcomes (OECD, 2021).

Profitability remains a core objective of every business organization, as it determines sustainability, growth potential, and the ability to reinvest in operations. Profitability reflects how efficiently a firm utilizes its resources to generate income above costs. Studies have shown that firms that prioritize product innovation tend to record improved sales volumes, customer loyalty, and operational efficiency, which ultimately translate into higher profitability (Akinwale & Adepoju, 2022). The pure water (sachet water) industry in Nigeria provides a

suitable context for examining the relationship between product innovation and profitability. In urban and semi-urban areas such as: Bida Metropolis, sachet water companies operate in a highly competitive market characterized by low entry barriers, similar product offerings, and price competition. As a result, firms are increasingly compelled to adopt innovative practices such as: improved water treatment processes, enhanced packaging, branding, and distribution strategies to gain competitive advantage and improve profit margins (Ogunleye & Owolabi, 2023). Despite the apparent importance of product innovation, many pure water companies still rely on traditional production methods with minimal emphasis on innovation, leading to reduced profitability and market stagnation. This study, therefore, seeks to examine the effect of product innovation on the profitability of business organizations, with specific reference to selected pure water companies in Bida Metropolis. By doing so, the study contributes to existing literature and provides practical insights for business owners, managers, and policymakers on how innovative

product strategies can enhance profitability and ensure business sustainability in a competitive environment.

Furthermore, limited managerial knowledge, financial constraints, and poor adoption of innovative technologies have hindered the implementation of effective product innovation strategies among pure water companies. As a result, firms struggle with declining sales, high operational costs, and weak competitive advantage (Ogunleye & Owolabi, 2023). This gap underscores the need for a focused investigation to determine how product innovation influences profitability and to provide evidence-based recommendations for improving business performance in the sector.

According to Schumpeter's theory of innovation, firms that continuously introduce innovative products are more likely to achieve competitive advantage and superior financial performance due to their ability to meet evolving market needs (Schumpeter, 1934). Contemporary studies have reaffirmed this position by emphasizing that innovation enables firms to differentiate their offerings, increase customer satisfaction, and sustain profitability in competitive markets (OECD, 2021).

Empirical studies conducted in developing economies indicate a strong positive relationship between product innovation and profitability. For instance, Akinwale and Adepoju (2022) found that small and medium-scale enterprises that invest in product innovation experience higher sales growth and improved profit margins compared to firms that rely on traditional production methods. Similarly, Adegbenmi and Ismail (2021) reported that product innovation enhances firm efficiency by reducing production waste and improving resource utilization, which ultimately contributes to increased profitability. These findings suggest that innovation is not limited to technological advancements alone but also includes incremental improvements that add value to products and processes. In the manufacturing and consumer goods sector, product innovation plays a significant role in shaping consumer perception and demand. Studies by Ogunleye and Owolabi (2023) revealed that firms that adopt innovative packaging, branding, and quality assurance measures are better positioned to attract customers and command premium prices. Innovative practices such as: improved filtration techniques, tamper-proof packaging, and compliance with regulatory

certifications have been identified as key drivers of market competitiveness and profitability (Nwankwo & Okorie, 2020).

Despite the documented benefits, several studies highlight challenges that hinder effective product innovation among small firms. Financial constraints, limited access to modern technology, and inadequate managerial skills have been identified as major barriers to innovation adoption in Nigerian enterprises (Olatunji & Adeyemi, 2022).

Concept of Product Innovation in Business Organizations: Product innovation in business organizations is fundamentally concerned with creating value for customers through the introduction of new products or significant improvement of existing ones. This value may arise from enhanced product quality, improved functionality, better packaging, or alignment with consumer preferences and regulatory standards. According to OECD (2021), product innovation enables firms to satisfy unmet market needs and respond proactively to environmental changes, thereby strengthening competitive positioning. In business organizations, product innovation serves as a strategic mechanism for differentiation, allowing firms to distinguish their offerings from competitors in saturated markets.

Empirical evidence suggests that organizations that embed innovation into their strategic orientation achieve higher market share and long-term profitability compared to non-innovative firms (Akinwale & Adepoju, 2022). Therefore, product innovation functions as a strategic asset that strengthens a firm's competitive edge and market relevance. Product innovation is also conceptualized as an organizational learning process that involves continuous knowledge acquisition, experimentation, and adaptation. Through innovation activities, firms learn from customer feedback, technological trends, and operational experiences, which improves future decision-making. According to Tidd and Bessant (2020), innovative firms develop dynamic capabilities that enable them to sense opportunities, seize them through new products, and reconfigure resources effectively.

Profitability and Performance Measurement in Manufacturing Firms: Profitability and performance measurement are central to assessing the success and sustainability of manufacturing firms. Common

profitability indicators include gross profit margin, net profit margin, return on assets, and return on investment, which collectively provide insight into financial health and operational efficiency (Pandey, 2021). In manufacturing firms, profitability is closely linked to production efficiency, cost control, product quality, and market demand.

In competitive industries, effective performance measurement enhances accountability and encourages continuous improvement. Studies indicate that firms that integrate innovation-related metrics into performance measurement systems are more likely to achieve superior profitability (OECD, 2021). Thus, profitability and performance measurement are interconnected tools that guide manufacturing firms toward efficiency, competitiveness, and long-term sustainability.

Product Innovation Strategies in the Pure Water Industry: The product innovation strategies in the pure water industries improvement in water treatment and purification technology. One major product innovation strategy in the pure water industry is the adoption of advanced water treatment and purification technologies. Improved filtration, reverse osmosis, and ultraviolet treatment enhance water quality and safety, which increases consumer confidence. Studies show that firms that invest in superior purification processes experience higher demand and improved profitability due to perceived product reliability (Nwankwo & Okorie, 2020).

Packaging innovation, including tamper-proof sachets, branded labels, and attractive designs, is another key strategy. Packaging serves not only as a protective medium but also as a marketing tool that differentiates products in a crowded market. Ogunleye and Owolabi (2023) note that strong branding and innovative packaging significantly influence consumer choice and willingness to pay.

Product variety enhances market reach and sales volume, especially in price-sensitive markets such as: Bida Metropolis. This flexibility enables firms to increase turnover and profitability (Akinwale & Adepoju, 2022). Innovation through compliance with regulatory standards, such as: NAFDAC certification, enhances product credibility. Certified products gain competitive advantage by assuring consumers of safety and quality, which positively impacts sales and profitability (OECD, 2021).

Innovative distribution strategies, including doorstep delivery and partnerships with retailers, improve product accessibility. Efficient distribution reduces stock shortages and expands market coverage, thereby increasing revenue generation (Olatunji & Adeyemi, 2022).

Challenges of Product Innovation in Small and Medium Enterprises: Limited access to finance is a major challenge facing SMEs in implementing product innovation. Innovation activities often require significant investment in technology, research, and skilled labor, which many SMEs cannot afford. Studies show that inadequate funding restricts innovation capacity and limits profitability growth (Akinwale & Adepoju, 2022). SMEs often lack structured research and development units, limiting their ability to generate and test new product ideas. This weakness reduces innovation output and market responsiveness (OECD, 2021).

Uncertain consumer demand and fear of innovation failure discourage SMEs from investing in new products. High risk perception negatively affects innovation decisions and long-term profitability (Pandey, 2021).

Prospects of Product Innovation in Small and Medium Enterprises: Product innovation enhances SMEs' ability to compete effectively by differentiating their products. Innovative firms attract more customers and achieve stronger market positions, leading to improved profitability (Porter, 2008).

Innovation-driven products generate higher sales volumes and profit margins. Empirical evidence confirms that innovative SMEs experience faster growth and financial sustainability (Akinwale & Adepoju, 2022).

Innovative products that meet consumer needs improve satisfaction and loyalty. Loyal customers provide stable revenue streams and reduce marketing costs, strengthening profitability (Kaplan & Norton, 2001).

Product innovation enables SMEs to adapt to regulatory changes, technological advancements, and shifting consumer preferences. This adaptability enhances business resilience and long-term survival (OECD, 2021).

Innovative SMEs contribute to job creation, income generation, and economic development. By improving productivity and profitability, SMEs play a critical role in national economic growth (Tidd & Bessant, 2020).

Theoretical Framework

1. Schumpeter's Innovation Theory: Schumpeter's Innovation Theory provides a strong theoretical foundation for examining the relationship between product innovation and profitability of business organizations. According to Schumpeter (1934), economic development is driven by innovation, which includes the introduction of new products, improvement in product quality, new production methods, and new market structures. Through innovative purification processes, packaging, and branding, firms can increase sales volume and profitability. Schumpeter's theory therefore explains how product innovation serves as a catalyst for improved financial performance and long-term sustainability of business organizations.

2. Resource-Based View (RBV) Theory: The Resource-Based View theory posits that firms achieve superior performance and profitability when they possess valuable, rare, inimitable, and non-substitutable resources (Barney, 1991). Product innovation is viewed as an outcome of effectively leveraging internal resources such as: technological capability, managerial expertise, and organizational knowledge. In the context of manufacturing firms and SMEs, product innovation reflects a firm's ability to transform its resources into unique products that competitors cannot easily replicate. For pure water companies, innovation in water treatment technology, packaging design, and quality assurance processes constitutes strategic resources that enhance competitive advantage. The RBV theory supports the topic by explaining how internally driven product innovation contributes to sustained profitability and improved organizational performance.

3. Dynamic Capabilities Theory: Dynamic Capabilities Theory extends the Resource-Based View by emphasizing a firm's ability to integrate, build, and reconfigure internal and external competencies in response to a changing environment (Teece, Pisano, & Shuen, 1997). This theory is particularly relevant in dynamic and competitive markets where consumer preferences and regulatory requirements frequently change. Product innovation is a manifestation of dynamic capabilities, as it enables firms to sense market opportunities, seize them through innovative products, and reconfigure resources accordingly. In the pure water industry, firms that can adapt quickly by improving product quality, packaging, and distribution are more likely to enhance profitability. Thus, the theory explains how continuous product innovation

supports organizational adaptability, competitiveness, and sustained profit growth.

Empirical Review: An empirical study by Akinwale and Adepoju (2022) examined the relationship between product innovation and firm performance among small and medium enterprises in Nigeria. This study empirically supports the view that product innovation is a critical driver of profitability in Nigerian business organizations. Adegbelemi and Ismail (2021) conducted an empirical investigation into innovation capability and profitability of manufacturing firms in emerging economies. The study revealed that product innovation significantly improves firm efficiency, reduces production costs, and enhances profitability. Ogunleye and Owolabi (2023) empirically examined competitive strategies and profitability of sachet water manufacturing firms in Nigeria. The study concluded that product innovation is essential for profitability and sustainability in the highly competitive pure water industry. This empirical evidence strongly supports the focus of the present study.

Summary: This study examined the effect of product innovation on the profitability of business organizations, with particular emphasis on manufacturing firms and the pure water industry. The discussion established that product innovation is a strategic tool that enables organizations to introduce new or significantly improved products that meet changing consumer needs and regulatory requirements. The literature reviewed showed that product innovation enhances value creation, strengthens competitive advantage, and promotes organizational learning. It also revealed that profitability and performance measurement are essential indicators of business success, as they reflect how efficiently firms utilize resources to achieve financial and operational goals. Empirical evidence from previous studies consistently demonstrated a positive relationship between product innovation and profitability, especially in small and medium enterprises. However, the study also highlighted significant challenges confronting SMEs, including financial constraints, limited technological capacity, weak managerial skills, and market uncertainty. Despite these challenges, the prospects of product innovation remain substantial, offering opportunities for improved profitability, customer satisfaction, adaptability, and contribution to economic development.

CONCLUSION

Based on the findings from the reviewed literature, it is evident that product innovation plays a vital role in enhancing the profitability and sustainability of business organizations. Firms that actively invest in product innovation are better positioned to respond to competitive pressures, improve product quality, and meet consumer expectations, which in turn leads to increased sales and profit margins. In manufacturing firms, particularly within the pure water industry, product innovation serves as a critical differentiating factor in a highly saturated market. Although small and medium enterprises face numerous constraints in implementing innovation strategies, the long-term benefits of product innovation outweigh the associated risks and costs. Therefore, product innovation should be regarded not as an optional activity but as a core strategic function that drives organizational performance and long-term growth.

RECOMMENDATIONS

1. Business organizations should allocate adequate financial resources specifically for product innovation activities, including research, product improvement, and technology acquisition, to enhance profitability and competitiveness.
2. Manufacturing firms, especially pure water companies, should invest in modern purification and packaging technologies to improve product quality, safety, and consumer confidence.
3. SME owners and managers should undergo continuous training in innovation management and strategic planning to strengthen their capacity to implement effective product innovation strategies.
4. Government and regulatory agencies should provide supportive policies, grants, and low-interest loans to encourage product innovation among small and medium enterprises.
5. Firms should integrate innovation-related indicators into their performance measurement systems to effectively track the impact of product innovation on profitability.

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EFFECTS OF EMPLOYEE JOB SATISFACTION ON ORGANIZATIONAL PERFORMANCE

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ABSTRACT

The impact of employee job satisfaction on organizational performance has been a focal point of research in recent years. This study investigates how various aspects of job satisfaction, including intrinsic and extrinsic factors, influence both individual and organizational outcomes. The review emphasizes the relevance of Herzberg's Two-Factor Theory and Social Exchange Theory in understanding how satisfaction in the workplace translates into improved productivity, innovation, and overall organizational performance. Job satisfaction leads to higher employee engagement, reduced turnover rates, and a positive work culture, which in turn boosts organizational success. Empirical studies from 2023 and 2024 support these claims, showing that organizations with satisfied employees experience improved performance across various dimensions, including productivity, innovation, and employee retention. The review also identifies recent trends, such as the growing importance of work-life balance and leadership styles in influencing job satisfaction. These trends point to a shift in how organizations manage employee well-being to enhance performance. The findings suggest that organizations must invest in both intrinsic and extrinsic factors to maximize the benefits of job satisfaction. Future research should continue to explore the evolving nature of job satisfaction, especially in the context of remote work and digital transformation. By aligning employee needs with organizational goals, companies can ensure long-term success and competitive advantage.

Keywords: Employee Job Satisfaction, Organizational Performance, Herzberg's Two-Factor Theory, Social Exchange Theory

INTRODUCTION

Employee job satisfaction has remained a critical issue in organizational studies, particularly within public sector institutions where performance outcomes directly affect service delivery and national development. Job satisfaction refers to the extent to which employees feel contented, motivated, and fulfilled with their jobs, work environment, and organizational practices (Singh *et al.*, 2023). In Nigeria, public institutions such as: tertiary institutions have continued to face challenges of declining performance, low morale, absenteeism, and reduced commitment among employees, which have been linked to inadequate attention to employee job satisfaction (Adebayo, 2021). Organizational performance in educational institutions goes beyond financial outcomes to include effectiveness in teaching, research output, administrative efficiency, and overall service delivery. Nigerian scholars have argued that when employees are satisfied with factors such as: remuneration, promotion opportunities, leadership style, job security, and working conditions, they tend to exhibit higher levels of commitment, efficiency, and productivity, which ultimately enhance organizational performance (Okoye & Ezejiofor, 2020). These challenges have raised concerns

about their implications for organizational performance in public educational institutions.

This study, therefore, seeks to examine the effect of employee job satisfaction on organizational performance, using the Federal Polytechnic, Bida as a case study. Despite the acknowledged importance of employee job satisfaction in enhancing organizational performance, many public sector institutions in Nigeria continue to experience persistent challenges related to low employee morale, poor commitment, and declining performance outcomes. In tertiary institutions such as: the Federal Polytechnic, Bida, issues such as: inadequate remuneration, delayed promotions, limited career advancement opportunities, poor working conditions, and inconsistent management practices have been reported to negatively affect employee job satisfaction. Nigerian studies have shown that dissatisfied employees are more likely to exhibit low productivity, absenteeism, and reduced commitment to organizational goals, which in turn undermines overall organizational performance (Adebayo, 2021).

Organizational performance in public educational institutions is increasingly threatened by industrial unrest,

high turnover intentions, and declining service quality, all of which are closely associated with low levels of job satisfaction among employees (Akinwale, 2022). Consequently, there is a need for an empirical investigation into the effect of employee job satisfaction on organizational performance in order to provide evidence-based recommendations for improving staff welfare, motivation, and institutional performance.

Employee job satisfaction has long been recognized as a key determinant of organizational success. Recent research continues to support the view that satisfied employees are more likely to contribute positively to organizational performance through increased productivity, creativity, and organizational commitment (Zhao et al., 2024). Studies have consistently found a positive relationship between job satisfaction and organizational performance. For instance, Chen and Zhang (2024) suggest that satisfied employees show greater organizational commitment, which reduces turnover rates and the associated costs of recruitment and training. These behaviours collectively enhance organizational outcomes by fostering a more collaborative and efficient work environment. Furthermore, Park et al. (2024) highlight the indirect effects of job satisfaction, such as: enhanced employee well-being and reduced absenteeism, both of which positively affect organizational performance. Employees who are satisfied with their jobs tend to experience lower stress levels and higher levels of motivation, which translate into improved work performance and higher organizational effectiveness (Nguyen et al., 2024).

Concept of Employee Job Satisfaction and Organizational Performance: Employee job satisfaction is defined as the overall emotional response an employee has toward their job, influenced by factors such as: work environment, compensation, relationships with colleagues, and opportunities for personal growth (Li & Wang, 2023). According to Chen and Zhang (2024), job satisfaction directly influences employees' organizational commitment and work engagement. Employees who are satisfied with their work tend to exhibit positive behaviors, such as: higher motivation and better work performance.

According to Nguyen *et al.* (2024), job satisfaction is not only about emotional fulfillment but also directly linked to employees' well-being. Satisfied employees tend to experience lower stress levels and a better work-life

balance, which enhances their mental and physical health. Organizational performance refers to how well an organization meets its objectives and goals, which can be measured in terms of efficiency, effectiveness, and overall output (Li & Wang, 2023).

Organizational performance can also be defined by how well an organization's resources, processes, and strategies align with its long-term goals (Park et al., 2024). A well-aligned strategy, combined with efficient resource management, results in optimal performance. Recent studies have pointed out that organizations achieving high levels of job satisfaction see better strategic execution because satisfied employees are more likely to understand and align with the company's objectives, contributing significantly to the organization's performance (Nguyen et al., 2024).

Impact of Job Satisfaction on Organizational Performance: Job satisfaction directly enhances employee productivity, as satisfied employees tend to be more engaged and focused on their tasks. According to Li and Wang (2023), satisfied employees are not only more productive but also show higher levels of creativity and initiative, contributing to the organization's overall efficiency. One of the most significant impacts of job satisfaction is its role in reducing absenteeism and turnover. Research by Chen and Zhang (2024) demonstrates that employees who are satisfied with their jobs are less likely to miss work and more likely to stay with the organization long-term. Lower turnover rates help organizations reduce recruitment and training costs, while also ensuring continuity in knowledge and expertise, which contributes to sustained organizational performance.

Job satisfaction is a key driver of employee engagement. Employees who are satisfied with their work are more likely to be highly engaged in their roles, showing greater dedication to achieving the organization's goals (Singh *et al.*, 2023).

Job satisfaction has been linked to higher levels of innovation and creativity, which are essential drivers of organizational success. Innovation is critical in competitive industries, and organizations that foster job satisfaction are more likely to experience growth and long-term success through continuous innovation.

Effects of Employee Job Satisfaction on Organizational Performance:

A direct effect of job satisfaction is the improvement in employee productivity. Satisfied employees are more likely to invest time and effort into their tasks, as they feel more motivated and valued by the organization. According to Singh *et al.*, (2023), job satisfaction leads to employees exhibiting higher levels of efficiency, taking fewer breaks, and showing greater dedication to their work. Job satisfaction directly impacts employee retention. Li and Wang (2023) indicate that satisfied employees are more likely to remain with the organization, reducing turnover rates. Job satisfaction plays a crucial role in enhancing an organization's reputation. Employees who are satisfied with their jobs are more likely to speak positively about their workplace, both internally and externally. According to Zhao *et al.*, (2024), organizations with high employee satisfaction tend to attract top talent, further improving their performance by hiring skilled employees. Additionally, a positive work environment can lead to better customer satisfaction, as employees are more likely to engage positively with clients and customers.

Chen and Zhang (2024) explain that committed employees are more likely to stay with the organization and put in discretionary effort to achieve organizational goals.

A positive work environment encourages open communication, reduces conflicts, and increases cooperation, all of which are critical to enhancing organizational efficiency, morale, and performance.

Recent Trends and Future Research Directions in Job Satisfaction and Organizational Performance:

The landscape of job satisfaction and organizational performance has significantly evolved in recent years, with several key trends emerging in 2023 and 2024. Nguyen *et al.*, (2024) explore how flexibility, autonomy, and work-life balance have become pivotal factors in job satisfaction. Employees now place higher value on these aspects, leading to improved performance outcomes in organizations that offer flexible work arrangements.

In line with these changes, there is a growing emphasis on employee well-being as a critical factor influencing job satisfaction. Research by Singh *et al.*, (2023) suggests that organizations that invest in employee mental health programmes and work-life balance initiatives see a direct

improvement in job satisfaction, which in turn enhances organizational performance.

Another trend is the increasing role of leadership in influencing job satisfaction and organizational performance. According to Li and Wang (2023), leadership style significantly impacts job satisfaction levels. Transformational leadership, characterized by motivation, support, and inspiration, is particularly effective in fostering employee satisfaction and performance. Research suggests that leaders who prioritize open communication and trust-building are more likely to see higher employee satisfaction, resulting in improved organizational outcomes.

Lastly, there is a growing interest in understanding the cultural and contextual factors that influence the relationship between job satisfaction and organizational performance. As global workforces become more diverse, future studies will need to examine how cultural differences affect job satisfaction and the subsequent impact on performance outcomes. This will be essential for organizations that aim to build a cohesive and high-performing workforce in a globalized economy.

Theoretical Framework

Herzberg's Two-Factor Theory (1959): Herzberg's Two-Factor Theory posits that job satisfaction and dissatisfaction arise from two distinct sets of factors: motivators and hygiene factors. According to this theory, intrinsic motivators such as: achievement, recognition, and personal growth contribute positively to job satisfaction and, consequently, to organizational performance (Herzberg, 1959). Conversely, hygiene factors such as: salary, working conditions, and job security, if inadequate, can lead to dissatisfaction but do not necessarily increase satisfaction when improved. In the context of organizational performance, Herzberg's theory suggests that while improving hygiene factors may reduce dissatisfaction, true performance improvements occur when motivators are enhanced. Recent studies have confirmed the continued relevance of this model, particularly in how organizations manage both intrinsic and extrinsic factors to boost performance (Singh *et al.*, 2023). Herzberg's framework provides a useful lens for understanding how organizations can enhance employee job satisfaction and, ultimately, improve organizational

outcomes by addressing both satisfaction and dissatisfaction factors.

Social Exchange Theory (Blau, 1964): Social Exchange Theory posits that the relationship between employees and employers is based on reciprocal exchanges. Employees offer their time, skills, and effort in exchange for rewards, such as: salary, job security, and recognition (Blau, 1964). If the perceived benefits from the employer are high, employees are more likely to reciprocate with high levels of job satisfaction, commitment, and performance. According to Nguyen et al. (2024), the quality of this exchange relationship impacts job satisfaction, which in turn influences organizational performance. This theory suggests that when organizations invest in their employees by providing meaningful rewards and supportive environments, employees will feel valued and perform better. In terms of organizational performance, this reciprocal process leads to higher engagement, commitment, and productivity, driving the organization's success. The theory highlights that the long-term performance of an organization is influenced by how well it maintains these reciprocal relationships with its employees.

Empirical Review: Li and Wang (2023) conducted a study examining the link between job satisfaction and innovation in high-tech industries. Their research concluded that employees who are satisfied with their jobs are more likely to engage in creative problem-solving and contribute innovative ideas to their organizations. The study suggests that fostering job satisfaction can significantly enhance organizational performance by driving innovation and improving operational outcomes. This aligns with Herzberg's Two-Factor Theory, which emphasizes the importance of intrinsic motivators in boosting organizational performance.

Zhao et al., (2024) focused on the healthcare sector and examined how employee job satisfaction influences organizational performance. Their study found that satisfied healthcare employees showed higher levels of patient care quality, reduced turnover rates, and greater organizational commitment, all of which contributed to enhanced organizational performance. This empirical evidence supports Social Exchange Theory, suggesting that when employees feel their needs are met by the

organization, they reciprocate with higher performance and a commitment to organizational success.

Singh et al., (2023) conducted an empirical study examining the relationship between job satisfaction and organizational performance with a specific focus on innovation in manufacturing firms. Their research indicated that employees who reported high levels of job satisfaction were significantly more likely to contribute to the organization's innovative efforts. Additionally, the study found that satisfied employees were more engaged in their work, which resulted in higher productivity and enhanced organizational performance. This empirical review corroborates the relevance of Herzberg's Two-Factor Theory, showing that intrinsic factors like recognition and achievement foster both job satisfaction and organizational performance.

Summary: This review explores the significant relationship between employee job satisfaction and organizational performance, emphasizing how satisfied employees contribute to an organization's success through improved productivity, reduced turnover, and enhanced innovation. Job satisfaction is a multifaceted construct that includes both intrinsic factors (e.g., achievement, recognition) and extrinsic factors (e.g., compensation, work environment) that affect employees' emotional responses and behaviors. The literature reviewed highlights several theories, including Herzberg's Two-Factor Theory and Social Exchange Theory, which provide insights into how job satisfaction influences organizational outcomes. Additionally, recent empirical studies confirm that job satisfaction enhances employee performance by fostering engagement, creativity, and loyalty, thereby contributing to higher organizational productivity and innovation. Satisfied employees also display positive behaviors such as: organizational citizenship behaviors (OCBs), which benefit the organization by promoting a supportive and efficient work environment.

CONCLUSION

The relationship between employee job satisfaction and organizational performance is undeniable. Employees who experience higher job satisfaction tend to be more engaged, productive, and committed, all of which enhance overall organizational performance. Factors such as: work-life balance, leadership style, and opportunities for career advancement are crucial for fostering job satisfaction.

Theories like Herzberg's Two-Factor Theory and Social Exchange Theory provide valuable frameworks for understanding the psychological mechanisms that drive this relationship. Organizations that prioritize improving job satisfaction are likely to experience reduced turnover, lower absenteeism, and a more motivated workforce. Therefore, enhancing job satisfaction is not only beneficial for employees but is also a key driver of organizational success.

RECOMMENDATIONS

1. To enhance both employee job satisfaction and organizational performance, organizations should prioritize fostering intrinsic motivation by offering recognition programmes, providing meaningful tasks, and supporting career development. By doing so, employees will feel valued and more engaged in their roles, leading to improved productivity and innovation.
2. Additionally, organizations must focus on improving work-life balance by offering flexible work arrangements and creating a supportive environment where employees can manage their personal and professional lives effectively. This has become increasingly important as employees seek more autonomy and control over their work schedules.
3. Competitive compensation and benefits packages also play a significant role in enhancing job satisfaction. Offering attractive wages, benefits, and performance-based incentives can motivate employees, particularly in industries where extrinsic factors are highly valued.
4. Finally, organizations should establish continuous feedback mechanisms and recognition systems. Regular feedback and acknowledgment of employees' efforts ensure that they feel valued and motivated to perform at their best. This will help sustain high levels of engagement and commitment, ultimately driving organizational success.

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EFFECT OF FIRM'S TANGIBILITY ON THE FINANCIAL PERFORMANCE OF ACCESS BANK OF NIGERIA PLC

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ABSTRACT

Tangibility is a critical determinant of firm performance because fixed assets enhance collateral value, support borrowing capacity, and influence operational scalability, particularly in capital-intensive sectors such as banking. This study investigated the effect of a firm's tangibility on the financial performance of Access Bank Nigeria Plc from 2013 to 2025 to assess the effect of tangibility on financial performance, measured by Return on Assets (ROA), Return on Equity (ROE), and Total Assets. The study employed time-series data involving 13 annual observations. Tangibility was measured by the ratio of non-current assets to total assets utilizing an ex-post facto research design. Ordinary Least Squares (OLS) regression and diagnostic tests were conducted to ensure result robustness. The results indicated that the impact of firm tangibility on the financial performance of Access Bank Nigeria Plc is minimal and statistically insignificant. This suggests that the bank's investment in fixed assets does not lead to increased returns. It is recommended that the bank focuses on maximizing intangible resources, advancing technological skills, and boosting operational effectiveness instead of increasing investments in fixed physical assets.

Keywords: Financial Performance, Tangibility, Firms, Return on Assets, Return on Equity.

INTRODUCTION

Tangibility is an increasingly researched area in business and corporate finance due to its relationship with the financial performance of firms (Boasiako et al., 2022; Docherty et al., 2010). Both tangible and intangible resources are crucial to a company's financial performance. Tangibility is defined as a component of a company's fixed assets, including land, buildings, and equipment, in relation to total assets (Almeida & Campello, 2018; Rajan & Zingales, 1995). These assets facilitate production activities and enhance borrowing capacity. Financial performance, typically measured as Return on Equity (ROE) and Return on Assets (ROA), reflects a company's capacity to achieve operational objectives.

A company is deemed competitive if it effectively manages both intangible and tangible assets (Herciu et al., 2012). Tangible assets are easier to collateralize, reducing losses during bankruptcy. In Nigeria, initiatives to create favorable business environments have led to varied financial outcomes (Irungu et al., 2018). Some researchers contend there is a significant negative correlation between tangibility and financial performance (Aamir & Muhammad, 2021).

This study is supported by the Resource-Based View (RBV), propounded by Birger (1984) and popularized by

Barney (1991). The RBV posits that corporate resources play a major role in creating a competitive edge. Physical assets are strategic resources used to improve operational capabilities. Furthermore, tangible assets allow firms to borrow at lower costs (İltaş & Demirgüneş, 2020). However, large investments in tangible assets may reduce innovation and flexibility, particularly in service-oriented industries like banking (Deng, et al., 2021).

As the world shifts toward knowledge-based economies, emphasis is placed on intangible assets such as R & D, human resources, and brand value (Intara & Suwansin, 2024). Recent research suggests intangible assets favorably impact financial performance (Ebe et al., 2023; Jo & Nugroho, 2025; Nguyen-Anh et al., 2022; Piekkola, 2024; Wang et al., 2022).

The examination of the effect of firm tangibility on the financial performance of Access Bank Plc is theoretically and empirically justified due to the bank's strategic position within the Nigerian banking industry and its substantial investment in tangible assets. Access Bank is among the largest Deposit Money Banks in Nigeria, with extensive investments in physical infrastructure, including branch network expansion, information technology systems, and digital banking facilities that support its operational efficiency and service delivery structure (Access Bank Plc, 2025).

From a financial theory perspective, tangibility is a critical determinant of firm performance because fixed assets enhance collateral value, support borrowing capacity, and influence operational scalability, particularly in capital-intensive sectors such as banking (Barney, 1991; Wernerfelt, 1984).

However, despite the strategic importance of tangible assets, empirical investigation into their effect on financial performance remains necessary because such investments may exert both positive and negative effects on profitability. On one hand, tangible assets can improve operational efficiency, customer service delivery, and long-term revenue generation (Mubyarto, 2020; Ramadan et al., 2022). On the other hand, excessive investment in fixed assets may reduce financial flexibility and profitability due to high depreciation charges, maintenance costs, and reduced liquidity positions (Tandra & Tjakrawala, 2020). This dual effect underscores the need for context-specific empirical analysis within the Nigerian banking environment.

The Nigerian banking sector is characterized by macroeconomic volatility, including persistent inflationary pressures, exchange rate fluctuations, and regulatory constraints imposed by the Central Bank of Nigeria. These conditions significantly affect asset utilization efficiency and financial performance outcomes of deposit money banks (Adekola & Obansa, 2017; Ajao & Akindele, 2020; Emecheta, & Ibe, 2014; Ogunleye & Adeleke, 2021; Owolabi & Adegbite, 2018; Sanusi, 2019). In such an unstable environment, the role of tangible assets becomes more complex, as banks must balance infrastructure expansion with liquidity management and profitability optimization.

In addition, recent corporate developments show that Access Bank Plc has actively pursued expansion through strategic acquisitions, including the acquisition of certain banking assets from Standard Chartered in countries such as Tanzania and Gambia. These cross-border expansion strategies have significantly strengthened the bank's asset

base and regional presence, while also increasing its exposure to diverse economic environments (Access Bank Plc, 2025). Such developments further reinforce the need to examine whether the expansion of tangible asset holdings translates into improved financial performance or introduces additional cost burdens. Therefore, investigating the effect of firm tangibility on the financial performance of Access Bank Plc is both timely and essential, as it provides empirical insight into how asset structure influences financial performance, in a rapidly evolving banking sector.

METHODOLOGY

The study employed a quantitative time series research design to examine how Access Bank Nigeria Plc's tangibility affected its financial performance from 2013 to 2025. A time series data is employed because it is thought to be appropriate for a single business observation, which allows for the examination of dynamic changes in financial performance as well as specific organizational characteristics (Stella and Eno 2024; Colma & Tale 2024). The study employed secondary data that was taken from 13 sets of annual observations found in Access Bank Nigeria Plc's audited annual reports and financial statement. That the sample size is rather small, is due to the fact that company time series investigations frequently function within associated inadequacies and that econometric estimate and diagnostic testing are used to achieve technique reliability.

To reduce omitted variable bias and improve model robustness, the following control variables were included: Firm Size (SIZE): natural logarithm of total assets, Financial Leverage (LEV): total debt divided by total assets and Inflation (INF): annual inflation rate (%). These variables are commonly used in corporate finance literature to control for macroeconomic and firm-specific influences on performance (Coad, et al., 2013; Majumdar, 1997).

Measurement and Operationalization of Variables.

The study employs ordinary least squares regression models of ROE and ROA as follows:

$$ROE_{it} = \beta_0 + \beta_1 TANG_{it} + \beta_2 SIZE_{it} + \beta_3 LEV_{it} + \beta_4 INF_{it} + \epsilon_{it} \quad (1)$$

$$ROA_{it} = \beta_0 + \beta_1 TANG_{it} + \beta_2 SIZE_{it} + \beta_3 LEV_{it} + \beta_4 INF_{it} + \epsilon_{it} \quad (2)$$

$$\text{Log}(\text{Total Assets}_{it}) = \beta_0 + \beta_1 \text{TANG}_{it} + \beta_2 \text{SIZE}_{it} + \beta_3 \text{LEV}_{it} + \beta_4 \text{INF}_{it} + \epsilon_{it} \quad (3)$$

The following are the measurement of the variables as they were used in the study.

Dependent variables:

ROA = Return on Assets (Financial Performance)

ROE = Return on Equity (Financial Performance)

TOTAL ASSETS = logarithm of total assets (Financial Performance)

Independent variables:

TANG = Tangibility

β_0 = Expected value on ROE and ROA

SIZE_t = Firm size

LEV_t = Financial leverage

INF_t = Inflation rate

ϵ_t = stochastic error term

Table 1. Descriptive Statistics of Tangibility, Financial Performance Indicators, and Firm Size of Access Bank Nigeria Plc. (2013–2025)

S/N	Years	Tangibility = Fixed Assets/Total Assets (Tang)	ROE = PAT/Total Equity	ROA = PAT/Total Assets	Firms Size = Log of Total Asset (sz)
1	2013	0.0394	0.1488	0.0213	1,704,094,012
2	2014	0.03515	0.1599	0.02168	1,981,955,730
3	2015	0.03041	0.0482	0.0272	2,411,944,061
4	2016	0.0272	0.1572	0.0231	3,094,960,515
5	2017	0.02779	0.1103	0.01467	3,499,583,979
6	2018	0.2228	0.16696	0.0185	3,968,114,609
7	2019	0.0299	0.1299	0.01111	6,307,588,216
8	2020	0.0252	0.1224	0.01049	7,624,979,718
9	2021	0.020089	0.1300	0.0115	9,660,760,559
10	2022	0.01955	0.1559	0.0133	12,535,280
11	2023	0.01344	0.3497	0.0259	20,649,112
12	2024	0.01937	0.0765	0.0059	27,681,603
13	2025	0.02075	0.0582	0.0045	25,435,262

Source: Annual reports, 2025.

Table1 clearly depicts various figures obtained from Access Bank's Annual reports for both firm's Tangibility

(IV) and Financial Performance (DV) used in this research work.

Table 2. Operational Definition of Variables, Measurement Proxies, and A Priori Expectations

S/N	VARIABLES	FORMULAR	VARIABLE (s)	APRIOPRI EXPECTATIONS
1	Total assets	Logarithm of Total Assets	Financial Performance (IV)	(Asad and Cheema, 2017;Purwohandoko,2017).
2	Return on Equity	Profit After tax/Total Equity	Financial Performance (IV)	(Irungu, <i>et al.</i> ,2018).
3	Return on Assets	Profit after Tax/Total Assets	Financial Performance (IV)	(Irungu, <i>et al.</i> ,2018).
3	Tangibility	Fixed Asset/Total Assets by 100	Tangibility (DV)	(Aamir, <i>et al.</i> ,2021; Irungu Muturi, <i>et al.</i> ,2018).

Table 2 shows measurement of variables. i.e. IV and DV as adapted by previous scholars such as Asad and

Cheema (2017); Purwohandoko (2017); Irungu *et al.* (2018) and Aamir, *et al.* (2021).

RESULTS AND DISCUSSION

Table: 3. Result of Analysis on Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Return on Equity (PAT/Total Equity)	13	.0482	.3497	.139535	.0743106
Return on Assets (PAT/Total Assets)	13	.0045	.0272	.016088	.0074061
LN of Total Assets	13	16.344	22.991	20.45262	2.558693
Tangibility (Fixed Assets/Total Assets)	13	.8671	.9788	.922792	.0287833
Valid N (listwise)	13				

This study examined the effect of firm tangibility on the financial performance of Access Bank Plc, using Return on Assets (ROA), Return on Equity (ROE), and the logarithm of total assets (LNTA) as indicators of financial performance. Firm tangibility was measured as the ratio of fixed assets to total assets. The descriptive statistics reveal that Access Bank Plc maintained a relatively high level of tangible assets, with an average tangibility ratio of 0.923 and a standard deviation of 0.029. The bank

recorded an average Return on Equity (ROE) of 0.140 with a standard deviation of 0.074, while Return on Assets (ROA) averaged 0.016 with a standard deviation of 0.007, indicating moderate profitability relative to shareholders' equity and total assets. Furthermore, the logarithm of total assets averaged 20.45 with a standard deviation of 2.56, reflecting substantial growth and accumulation of assets during the study period.

Table: 4. Correlations Analysis

		Tangibility (Fixed Assets/Total Assets)	Return on Equity (PAT/Total Equity)	Return on Assets (PAT/Total Assets)	LN of Total Assets
Tangibility (Fixed Assets/Total Assets)	Pearson Correlation	1	.086	.146	.060
	Sig. (2-tailed)		.781	.635	.845
	N	13	13	13	13
Return on Equity (PAT/Total Equity)	Pearson Correlation	.086	1	.480	-.209
	Sig. (2-tailed)	.781		.097	.493
	N	13	13	13	13
Return on Assets (PAT/Total Assets)	Pearson Correlation	.146	.480	1	.212
	Sig. (2-tailed)	.635	.097		.487
	N	13	13	13	13
LN of Total Assets	Pearson Correlation	.060	-.209	.212	1
	Sig. (2-tailed)	.845	.493	.487	
	N	13	13	13	13

The correlation analysis revealed weak positive relationships between firm tangibility and the selected indicators of financial performance, namely Return on Assets (ROA) ($r = 0.146$, $p = 0.635$), Return on Equity (ROE) ($r = 0.086$, $p = 0.781$), and total assets ($r = 0.060$, $p = 0.845$). These findings imply that increases in fixed

assets are associated with only marginal improvements in the financial performance of Access Bank Plc. However, the relationships were statistically insignificant, suggesting that firm tangibility does not significantly explain variations in the bank's financial performance indicators.

TABLE 5. Analysis on Regression

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.146 ^a	.021	-.068	.0076531

a. Predictors: (Constant), Tangibility (Fixed Assets/Total Assets)

ANOVA^a

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	.000	1	.000	.238	.635 ^b
	Residual	.001	11	.000		
	Total	.001	12			

a. Dependent Variable: Return on Assets (PAT/Total Assets)

b. Predictors: (Constant), Tangibility (Fixed Assets/Total Assets)

Regression results reinforce the correlation findings.

Tangibility accounts for:

-2.1% of the variation in ROA ($R^2 = 0.021$, $F = 0.238$, $p = 0.635$)

0.7% of the variation in ROE ($R^2 = 0.007$, $F = 0.081$, $p = 0.781$)

0.4% of the variation in total assets ($R^2 = 0.004$, $F = 0.040$, $p = 0.845$)

The coefficients of tangibility are positive but not statistically significant in any model (ROA $\beta = 0.037$, $p = 0.635$; ROE $\beta = 0.221$, $p = 0.781$; Total Assets $\beta = 5.341$, $p = 0.845$), confirming that tangibility does not significantly influence the bank's financial performance.

The result shows that firm's tangibility has a weak and positive effect on the Return on Assets, Return on Equity and Total Assets of the bank and this is consistent with the following findings (Majumdar, 1997; Gleason, et al., 2000; Tian & Zeitun, 2007). These findings are however, the expected in the banking sector where non-physical resources like loan portfolios, technological infrastructure and human resources usually contribute more to profitability than tangible assets (Arianpoor, 2021; Villalonga, 2004; Jeet & Aspal, 2021). In contrast to manufacturing or industrial companies, which rely heavily on fixed assets for production (Margaritis & Psillaki, 2010; Zeitun & Tian, 2007; Simerly & Li, 2000), Banks primarily improve their performance through service quality, loan management, and operational effectiveness. The minor influence of tangibility suggests that Access Bank's allocation toward fixed assets does not result in proportionately greater returns on equity or total assets. Viewing this from a managerial angle, these findings imply that a strategic focus should be directed

toward maximizing intangible assets, boosting technological advancements, and refining operational processes rather than increasing investments in fixed assets.

The findings indicate that although tangibility is a critical component of the bank's assets, it does not significantly influence the Return on Assets, Return on Equity, and Total Assets of Access Bank Nigeria Plc. Future studies might investigate how intangible assets and technological advancements influence financial performance, particularly within the context of Nigeria's banking industry.

CONCLUSION AND RECOMMENDATIONS

The study investigated how the tangible assets of Access Bank Nigeria Plc influence its financial results. From 2013 to 2025, the descriptive analysis reveals that Access Bank consistently holds a significant amount of tangible assets, with a tangibility ratio averaging 0.923 ($SD = 0.029$). The return on equity (ROE) for the bank had an average of 0.140 ($SD = 0.074$), and the return on assets (ROA) averaged 0.016 ($SD = 0.007$), indicating a moderate level of profitability in terms of both equity and assets. The total assets, represented in logarithmic format, had an average of 20.45 ($SD = 2.56$), demonstrating considerable growth in asset accumulation throughout the period.

While, Correlation results indicate a weak, positive relationship between tangibility and financial performance indicators: ROA ($r = 0.146$, $p = 0.635$), ROE ($r = 0.086$, $p = 0.781$), and total assets ($r = 0.060$, $p = 0.845$). These coefficients signify that increases in fixed assets are only minimally associated with increase in

financial performance. Importantly, the relationships are not statistically significant, indicating that tangibility alone does not strongly explain variations in the bank's performance metrics.

Furthermore, the regression result also reinforces the correlation findings. Tangibility accounts for: 2.1% of the variation in ROA ($R^2 = 0.021$, $F = 0.238$, $p = 0.635$), 0.7% of the variation in ROE ($R^2 = 0.007$, $F = 0.081$, $p = 0.781$) and 0.4% of the variation in total assets ($R^2 = 0.004$, $F = 0.040$, $p = 0.845$)

The following are the summary of research findings:

1. Firm tangibility exerts a weak and statistically insignificant influence on the financial performance of Access Bank Plc.
2. The insignificant effect of firm tangibility on the financial performance of Access Bank Plc indicates that the bank's investment in fixed assets does not substantially contribute to improvements in return on assets (ROA), return on equity (ROE), or growth in total assets.

The following recommendations are proposed based on the findings of the study:

1. Access Bank Plc and other financial institutions should prioritize the optimization of intangible resources, technological capabilities, and operational efficiency rather than concentrating excessively on investments in fixed assets.
2. Intangible assets such as software technology, human capital, and loan portfolios exert a more significant influence on profitability and financial performance than tangible assets within the banking sector. Unlike manufacturing and industrial firms, which depend substantially on fixed assets for production activities, banks primarily enhance their performance through efficient service delivery, effective credit management, and operational efficiency.
3. Future research should examine the comparative effects of intangible resources and technological investments on financial performance, particularly within the Nigerian banking industry, in order to provide deeper empirical insights into the determinants of banking sector performance.

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AN EMPIRICAL STUDY OF THE IMPACT OF COMPENSATION MANAGEMENT ON THE FINANCIAL PERFORMANCE OF ACCESS BANK NIGERIA PLC.

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ABSTRACT

This study examines the relationship between compensation management and the financial performance of Access Bank Nigeria Plc over the period 2013–2025. The study adopts an ex post facto research design using secondary data derived from the bank's audited annual reports. Financial performance is proxied by Return on Assets (ROA), Return on Equity (ROE), and Total Assets, while compensation management is measured using retirement benefit obligations. The empirical analysis employs descriptive statistics, correlation analysis, and ordinary least squares (OLS) regression techniques. Findings reveal a positive and statistically significant relationship between retirement benefits and both ROA and ROE, indicating that improved compensation structures enhance profitability and shareholder value creation. However, the effect of retirement benefits on total assets is positive but statistically insignificant, suggesting limited influence on firm expansion. The study concludes that while compensation management significantly enhances financial performance, its effect on asset growth is weak. It is recommended that banks strengthen their compensation frameworks to enhance employee commitment and long-term financial performance.

Keywords: Compensation Management, ROA, ROE, Retirement Benefits, Financial Performance, Firm Size.

INTRODUCTION

Financial performance remains a central construct in corporate finance and strategic management; as it reflects the extent to which firms efficiently utilize resources to achieve profitability and shareholder wealth maximization (Brigham & Houston, 2022). It is commonly assessed using accounting-based indicators such as Return on Assets (ROA), Return on Equity (ROE), and total assets. ROA measures managerial efficiency in utilizing total assets to generate earnings, while ROE evaluates the return generated for shareholders based on equity investment (Ross et al., 2021). Total assets, on the other hand, reflect the firm's resource base and operational capacity, which often determines its expansion potential

According to Ethelmary, et al.,(2025), compensation management is seen as one of the most crucial and effective programs, particularly for the aim of boosting worker productivity. It is one of the most important tools that a company must pay close attention to. However, it lists the required wage and the potential benefits that employees might get in a certain position. It encompasses every aspect of planning and managing the financial worth that is given to employees in exchange for their labor. Adeoye (2019) describes it as a reward given to workers in a business for carrying out a certain task. Bob (2021) states that it involves evaluating pay, establishing

structures, values, competencies, productivity, skills, and the advantages that employees are likely to get. As a result, compensation management and administration in an organization includes non-monetary rewards as well as monetary payments that affect both intrinsic and extrinsic motivation in order to enhance employee performance. In conclusion, it is the most effective method for capturing employees' attention inside a business, particularly in terms of teaching them about possible attitudes and behaviors (Shell & Solomon, 2017). Inadequate employee benefits and pay will certainly result in poor productivity, which can result in absenteeism and unhappiness (Ethelmary et al.,2025). It's enough to state that there's a connection between the financial success of the business and that of its workforce. The capacity of an employee to accomplish defined goals or targets of assignments or tasks assigned to them within a certain time frame is what is meant by employee performance (Ethelmary, et al.,2025). The idea of performance, which often has several dimensions depending on the kind of company, may be seen as the extent to which particular goals or objectives are achieved. In terms of ideas, employee performance is assessed using variables like productivity, the customer satisfaction index, level of achievement, and target (Ogbogu, & Sadamoro, 2022). The primary measure of an employee's performance is the quantity and quality of work they produce in a specific period of time. (Rohrer & Putteril, 2015). Previous studies have shown a

strong link between staff performance and an organization's compensation management (Shin, Rong, & Chin-wei, 2012). In conclusion, a worker's performance is directly related to their technical knowledge, abilities, talents, interests, and efforts. Consequently, the contributions of higher-paid workers are seen as more valuable and significant than those of lower-paid workers. (Ogbogu & Sadamoro, 2022). A payment scheme that is both advantageous and fiercely competitive has a strong correlation with company growth and success (Mayson & Barret, 2006). For this reason, it is essential for any company looking to improve its financial situation or performance to give its pay structure significant thought. If the company wishes to keep a very productive workforce, the compensation plan should be based on performance-based pay.

Equity Theory (Adams, 1963) provides the theoretical foundation for this study. It argues that employees evaluate fairness by comparing their inputs and outputs relative to others. Perceived inequity in compensation may reduce motivation, whereas fair compensation enhances commitment and productivity. Aside this Retirement Benefits is one of the most significant factors that can influence financial performance of firms (Adams, 1963; Armstrong & Taylor, 2023). Scholars have argued that organizations must give considerable attention to employees' retirement benefits in order to reduce post-retirement anxiety, enhance commitment to organizational objectives, promote financial security, and improve the financial performance of firms. (Niwahabwe & Alex, 2025). It has also been argued that compensation management includes retirement benefits and pension schemes, which serve as important mechanisms for improving financial performance (Dessler, 2020; Samuel et al., 2022); Ethelmary et al., 2025).

Despite extensive literature, empirical evidence on the banking sector in Nigeria remains limited. Therefore, this study investigates the impact of retirement benefits on ROA, ROE, and total assets of Access Bank Nigeria Plc. (Niwahabwe & Alex, 2025; Dessler, 2020; Ethelmary et al., 2025).

An organization needs an efficient and effective compensation system if it hopes to compete effectively

with other related commercial entities. This is because it has a direct impact on the financial success of the company (Ugowe et al., 2025). The study aims to accomplish the following: (i) determine how Retirement Benefits impact Access Bank Nigeria Plc's return on assets; and (ii) analyze the correlation between Retirement Benefits and return on equity. (iii) To assess the effect of retirement benefits on Access Bank Nigeria Plc's overall assets.

METHODOLOGY

The study employed a quantitative time series research design to examine how Access Bank Nigeria Plc's Compensation Management affected its financial performance from 2013 to 2025. A time series data is employed because it is thought to be appropriate for a single business observation, which allows for the examination of dynamic changes in financial performance as well as specific organizational characteristics (Stella and Eno 2024; Colma & Tale 2024)

The study employed secondary data that was taken from 13 sets of annual observations found in Access Bank Nigeria Plc's audited annual reports and financial statement. A longitudinal research design was employed and Descriptive statistics, correlation and Regression analysis were used for the study. Although the sample size is rather small, this is due to the fact that company time series investigations frequently function within associated inadequacies and that econometric estimate and diagnostic testing are used to achieve technique reliability.

To reduce omitted variable bias and improve model robustness, the following control variables were included:

1. Firm Size (SIZE): natural logarithm of total assets,
2. Financial Leverage (LEV): total debt divided by total assets.

These variables are commonly used in corporate finance literature to control for macroeconomic and firm-specific influences on performance (Coad, et al., 2013; Majumdar, 1997).

Measurement and Operationalization of Variables:

The study employs ordinary least squares regression models of ROE and ROA as follows:

$$ROE_{it} = \beta_0 + \beta_1 RBit + \beta_2 SIZE_{it} + \beta_3 LEV_{it} + \varepsilon_{it} \quad (1)$$

$$ROAi = \beta_0 + \beta_1 RB_{it} + \beta_2 SIZE_{it} + \beta_3 LEV_{it} + \varepsilon_{it} \quad (2)$$

$$LogTotalAssets_{it} = \beta_0 + \beta_1 RB_{it} + \beta_2 SIZE_{it} + \beta_3 LEV_{it} + \varepsilon_{it} \quad (3)$$

The following are the measurement of the variables as they were used in the study.

Dependent variables.

ROA = Return on Assets (Financial Performance)

ROE = Return on Equity (Financial Performance)

TOTAL ASSETS = logarithm of total assets (Financial Performance)

Independent variables.

RB = Retirement Benefits Obligation

β_0 = Expected value on ROE, ROA and Total Assets

$SIZE_t$ = Firm size

LEV_t = Financial leverage

ε_t = error term

Table 1. Measurement of Variables and financial Data obtained from Annual reports of Access Bank Nigeria Plc.

S/N	YEARS	Retirement Benefits & Obligations (RB)	ROE = PAT/TOTAL EQUITY	ROA = PAT/TOTAL ASSETS	FIRMS SIZE = LOG. OF TOTAL ASSET (sz)
1	2013	-----	0.1488	0.0213	1,704,094,012
2	2014	3,267,364	0.1599	0.02168	1,981,955,730
3	2015	5,567,800	0.0482	0.0272	2,411,944,061
4	2016	3,064,597	0.1572	0.0231	3,094,960,515
5	2017	2,481,916	0.1103	0.01467	3,499,583,979
6	2018	2,319,707	0.16696	0.0185	3,968,114,609
7	2019	3,418,060	0.1299	0.01111	6,307,588,216
8	2020	4,584,149	0.1224	0.01049	7,624,979,718
9	2021	3,845,942	0.1300	0.0115	9,660,760,559
10	2022	3,244,000	0.1559	0.0133	12,535,280
11	2023	8,480,000	0.3497	0.0259	20,649,112
12	2024	1,559,000	0.0765	0.0059	27,681,603
13	2025	11,121,00	0.0582	0.0045	25,435,262

RESULT AND DISCUSSIONS

Table 2. Analysis on Descriptive Statistics

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Return on Equity (PAT/Total Equity)	13	.0482	.3497	.139535	.0743106
Return on Assets (PAT/Total Assets)	13	.0045	.0272	.016088	.0074061
Lsize	13	16.34	22.99	20.4526	2.55869
LRB	12	13.92	15.95	14.9601	.54142
Valid N (listwise)	12				

This study investigated on the relationship between compensation management proxies by Retirements benefits (RB) and financial performance of Access Bank Nigeria Plc from 2013-2025. Descriptive statistics result shows that Retirement Benefits is positively and significantly related to financial performance of firms. Overall, the data suggest potential linkage between compensation practices and financial performance

Table 3. Analysis on Correlation analysis

Correlations

		Return on Equity (PAT/Total Equity)	Return on Assets (PAT/Total Assets)	LRB
Return on Equity (PAT/Total Equity)	Pearson Correlation	1	.480	.596*
	Sig. (2-tailed)		.097	.041
	N	13	13	12
Return on Assets (PAT/Total Assets)	Pearson Correlation	.480	1	.697*
	Sig. (2-tailed)	.097		.012
	N	13	13	12
LRB	Pearson Correlation	.596*	.697*	1
	Sig. (2-tailed)	.041	.012	
	N	12	12	12

* Correlation is significant at the 0.05 level (2-tailed).

The analysis of correlation results also indicated that RBs are significantly and positively related with both Return on Assets (ROA) ($r = 0.697$, $p < 0.05$) and Return on Equity (ROE) ($r = 0.596$, $p < 0.05$), which means that an increase in compensation related obligations automatically and proportionately associated with increased in financial

performance. This implies that increases in retirement benefit obligations are associated with improved financial performance indicators, supporting the view that compensation enhances employee productivity, organizational efficiency or financial Performance (Adams, 1963; Armstrong & Taylor, 2023).

Table 4. Regression Analysis

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.693 ^a	.481	.365	.0617924

a. Predictors: (Constant), LRB, Lsize

ANOVA^a

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	.032	2	.016	4.165	.052 ^b
	Residual	.034	9	.004		
	Total	.066	11			

a. Dependent Variable: Return on Equity (PAT/Total Equity)

b. Predictors: (Constant), LRB, Lsize

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	-1.095	.516		-2.122	.063
	Lsize	-.011	.007	-.363	-1.475	.174
	LRB	.097	.035	.676	2.746	.023

a. Dependent Variable: Return on Equity (PAT/Total Equity)

The analysis of regression also supports the above results which indicated that RBs is positive and statistically significant on ROA ($\beta = 0.010$, $p = 0.012$; $R^2 = 0.485$) and ROE ($\beta = 0.085$, $p = 0.041$; $R^2 = 0.355$).

Furthermore, the influence of retirement benefits on firm's size is positive but with statistically insignificant relationship with ($\beta = 1.087$, $p = 0.490$). While, the result of multiple regression results with firm size as control variable also depicted that RBs remains to be major or significant predictor of ROE ($\beta = 0.097$, $p = 0.023$), though, firm size does not depict any significance influence on financial performance,

The main findings include:

1. Retirement benefits positively and significantly influence ROE ($\beta = 0.097$, $p = 0.023$)
2. Firm size shows a negative but insignificant effect on ROE
3. Model significance is marginal ($F = 4.165$, $p = 0.052$)
4. Although firm size is not statistically significant, retirement benefits remain a strong predictor of financial performance, reinforcing the strategic importance of compensation management.

These findings align with Armstrong and Taylor (2023), who argue that effective compensation systems enhance employee motivation and organizational performance. The analysis of the result suggest that compensation management is critical and essential for enhance financial performance, although, it does not significantly affect firm's growth and expansions

CONCLUSION AND RECOMMENDATIONS

The study concludes that retirement benefits have a statistically significant positive effect on ROA and ROE, but an insignificant effect on total assets. Thus, compensation management plays a critical role in enhancing financial performance but has limited influence on asset growth.

- i. Banks should strengthen compensation structures to enhance employee commitment and productivity.
- ii. Competitive retirement benefit schemes should be maintained to improve staff retention.
- iii. Performance-based compensation systems should be implemented to reward productivity.
- iv. Employees demonstrating high performance should be regularly rewarded to sustain motivation.

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SUSTAINABLE BIOGAS PRODUCTION FROM SWEET POTATO PROCESSING WASTE

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ABSTRACT

Escalating global energy crisis coupled with pressing environmental concerns has accelerated the transition towards sustainable, eco-friendly and economically viable energy sources. This study evaluated the potentials of sweet potato peels, a widely available agricultural residue as a substrate for biogas generation using a laboratory scale batch anaerobic digester under mesophilic conditions. Prior to digestion, the substrate was pre-treated and co-digested with cow dung at a 1:2 ratio over a 25-day retention period, to enhance microbial activity and process stability. Biogas yield, pH and temperature were recorded daily to assess digester performance. To improve the biogas quality, the raw biogas was upgraded through sequential treatment using an iron sponge for H₂S removal and water scrubbing for CO₂ removal. Gas production commenced within 48 hours, indicating quick substrate degradability. Comparative biogas analysis before and after purification revealed a substantial enrichment in methane content from 57.21 % to 84.32%, CO₂ and H₂S were significantly reduced from 30.2% to 1.9% and from 1,93ppm to 0.04ppm respectively. These findings demonstrate that pretreated sweet potato peels co-digested with cow dung can deliver high quality biogas within a relatively short retention time, supporting their viability as a sustainable energy feedstock. The purification process effectively removed noncombustible and toxic constituents, thereby enhancing its quality. Trace contaminants including carbon monoxide (0.03 ppm), nitrogen oxides (NO = 1.36 ppm, NO₂ = 0.82 ppm, NO_x = 2.18 ppm), and volatile organic compounds (8.55 ppm), were present at minimal concentrations that can be useful for domestic use. The slight elevated oxygen level detected was attributed to sampling contamination and did not compromise the methane concentration. Collectively the results confirmed that sweet potato peels are viable substrate for biogas production and upgrading the biogas further increase the methane content to level suitable for domestic and small-scale applications. These findings suggest that sweet potato peels can serve as a sustainable waste to energy resource for decentralized biogas systems for rural energy security, sustainability and waste management.

Keywords: sustainable, biogas, sweet potato peels, digester, scrubbing, purification

INTRODUCTION

In recent times, the world's demand for energy and challenges of climate change has posed significant challenges globally, with predictions of possible energy shortage in the future (Oluwatoyin, 2023). Experts warn that natural gas reserves may be depleted within 50 years, while crude oil reserves could be exhausted within 40-70 years, this could lead to a global temperature increase of 1.8-6.4°C by 2100 (Sunarso *et al*, 2012). According to World Population Prospects (2017), the world's population is expected to reach 8.6 billion by 2030, 9.8 billion by 2050, and 11.2 billion by 2100, putting more demand on resources and energy. This growth has sparked interest in renewables energy and biogas is presumed as sustainable solution. Biogas is produced through anaerobic digestion of organic materials such as sewage sludge, animal waste, agricultural waste and municipal solid waste (MSW), offering a promising alternative (Valijanjan *et al*, 2018). Sweet potato peels are parts of agricultural wastes that are rich in starch, as well as cellulose, hemicellulose and protein with small

amounts of lignin. These components provide the carbon compounds needed during anaerobic digestion to facilitate microbial activity (Jabeen *et al.*, 2000).

As a sustainable and environmentally friendly energy source, biogas plays a vital role in generating heat and electricity, it is also recognized as one of the most promising renewable energy options globally (Tufaner and Demirci, 2020). Biogas is generated using anaerobic digestion of organic matter, such as manure, municipal solid waste, sewage sludge, biodegradable waste, and agricultural slurry under anaerobic conditions with the assistance of microorganisms (Dong *et al*, 2020). The process is divided into four sequential steps, performed by different anaerobic microorganisms in microbial community: hydrolysis, acidogenesis, acetogenesis and methanogenesis (Labatut and Pronto 2018).

The process leverages microorganisms to break down organic matter in the substrates, offering a cleaner, environmentally friendly alternative to traditional energy

sources. Biogas composed primarily of methane (45-75%) and carbon dioxide (25-55%), with smaller amounts of hydrogen sulfide, water, and other trace gases (Ayoub 2002). Its industrial-scale production has surged due to its perceived potentials as fuel and energy source; it also plays a positive role in reducing greenhouse gas emissions when captured and utilized as fuel.

Biogas requires purification when the intent of its application is for energy generation. Purification of raw biogas will increase the methane content thereby increase the energy value of the sample. Carbon dioxide, makeup 30-45 % of biogas, which is not desirable, because it doused methane efficiency and reduce engine performance. Hydrogen sulfide can also cause wear and tear on machine parts, because of its ability to form corrosive sulfur dioxide when combusted. Removing these impurities became crucial to optimize biogas performance as a fuel. When carbon dioxide is removed from biogas, methane content increases, resulting into a higher power output. However, iron filling can effectively remove hydrogen sulfide that constituted 0.1 % (1000 ppm) or more as the case may be, to avert engine damage. Applying simple water scrubbing techniques can

effectively remove carbon dioxide to enhance its quality when use for either heat or electricity generation.

METHODOLOGY

Substrate Collection and Preparation: The sweet potato peels used was obtained from local agricultural processing centers in Bida, Niger state, Nigeria. The peel was sun-dried for 2 days, 8 hours daily. Then, the dried peel was grounded with electric vegetable grinder to finer particles. Fresh Cow dung obtained from nearby cattle farm was used as inoculum to provide initial microbial consortium to the system due to high population of methanogenic bacteria present in the cow dung (Weiland, 2010). The mixing ratio of the substrate to inoculum was 1:2 on a weight-to-weight basis (w/w), as suggested by (Surendra et al., 2014)

Digester Setup and Operation: The anaerobic digester used was a plastic container with a working volume of 2 liters. Inlet pipe and outlet pipe were incorporated into it. The outlet was connected to gas sampling bags and then passed to purification units.

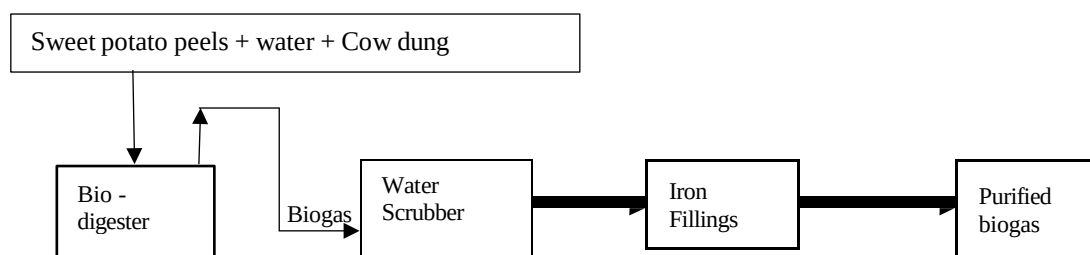


Figure 1: Block diagram of biogas production and purification

Digester/Substrate Loading: The digester was loaded with 150 g of potato peels, 300 g cow dung and 450 ml of water. The mixture was thoroughly mixed and pH of the mixed slurry was measured. The digester was then air tight and operated anaerobically for 25 days under mesophilic conditions. Daily gas production was monitored, measured and recorded. After each measurement the digester slurry were shaken and mixed thoroughly before the next reading was taken to promote uniform microbial activity. The pH and temperature were also monitored on daily basis.

Biogas Purification Procedure: The biogas produced underwent through a sequential purification step of

desulfurization and carbon dioxide scrubbing in order to enhance the quality of the biogas produced.

Desulfurization: The raw biogas was passed through an iron sponge scrubber to remove hydrogen sulfide (H_2S) to limit the corrosiveness and toxicity of the biogas. Iron oxide in the sponge reacts chemically with H_2S , converting it to iron sulfide and water. The iron sponges enclosed in an air tight container through which the biogas flows to the top is called the dry box method. The gas flows through the ferrous bed from the bottom and leaves the container at the top, where the Sulphur component in the biogas reacted with iron bed to give output gas with minimal or free of H_2S . The absorbing material was

regenerated by treating the sulphurated absorbent with atmospheric oxygen, thereby, returned it to its active oxide form required for further purification of gas.

Carbon Dioxide Removal: The biogas produced was passed through a water scrubbing column, where CO₂ dissolves in water, to increase the methane concentration in the biogas. Here, CO₂ is dissolved in water as the biogas passed upward through a packed column of downward-flowing water. This improves the methane concentration in the biogas.

Analysis of the biogas: The measurement and characterization of biogas are essential to evaluate the efficiency of the anaerobic digestion process. Several analytical methods were used in this study to determine the volume, composition, and operating parameters of the digester system. These methods are vital for understanding the suitability of the substrate in biogas production.

Daily Gas Yield: The biogas produced was collected through a gas outlet hose into a gas collection bag. The weight of the gas was measured daily by the use of weighing balance. The difference in mass of the collection container before and after gas collection. The cumulative gas yield was calculated over time.

Determination of Biogas Composition : The sample of the gas produced was analyzed using Gas Chromatography (GC) to ascertain the quantity of methane (CH₄), carbon dioxide (CO₂), hydrogen sulfide (H₂S) and impurities that are present at the end of retention times. Gas chromatography is an instrument use to identify and quantify of each component of the biogas produced. In this method, a small sample of biogas is injected into the chromatograph, where it passes through a stationary phase in a column. Each component (CH₄, CO₂, H₂S, etc.) moves at a different speed and exits the column at a different time, called the retention time. A thermal conductivity detector (TCD) or flame ionization detector (FID) measures the concentration of each component.

The pH of Digester Slurry: The slurry's pH was measured using a calibrated digital pH meter, before each measurement, the meter was calibrated using standard buffer solutions (pH 4.0, 7.0, and 10.0). Samples were

stirred and readings were taken after stabilization (about 30 seconds). pH was recorded every day throughout digestion period to monitor acidity or alkalinity of the medium.

RESULTS AND DISCUSSION

The result of this study showed that, the cumulative biogas yield from sweet potato peel was 2.31 liters after the retention period of 25 days. Figure 1 showed the gas yield as a function of time.

Gas Yield as Function of Time: From figure 1, the daily biogas yield from potato peels showed a progressive growth from the 3rd day after the lag period of 2 days, when the initial volume of biogas was recorded. As the gas production commenced on the 3rd day with a total yield of 0.0434 liters. The yield was observed to increase steadily to a maximum value of 0.2609 liter on the 9th day of retention, which correspond to the highest methanogenic activity seen throughout the digestion period. This increase attested to the readily available components that are soluble within potato as substrate. The other lignocellulosic part of the substrate was slowly degraded for microbial consumption thereby led to the decrease in biogas production for the subsequent days of retention. It was after the 9th day that, the gas production showed a gradual decline to 0.2174 liters and continued to decline until near-zero on the 23rd day of digestion. A clear prove to the fact that, most of the easily hydrolysable component of the substrates are consumed within the first nine days and transition to slower degradation, signifies that, there are more resistant components within the digester slurry or more harmful chemical are produced in the system that was capable of retarding the digestion. This trend is typical for most of the batch mesophilic digestion systems, where substrate availability determined the rate at which the subsequent stage of digestion will be geared towards (Bouallagui *et al.*, 2005). At the end, sweet potato peels demonstrated quick onset of biogas yield and attained peak in a minimal retention period when compared to lignocellulosic materials that typically exhibit a lag phase of 2 – 5 days before digestion due to slow hydrolysis (Matheri *et al.*, 2016), while sweet potato peels produced biogas within 48 hours. The decrease observed in gas yield after day 18 of digestion, may be attributed to limited biodegradable organic matter left within the system or possibly acid accumulation in the digester.

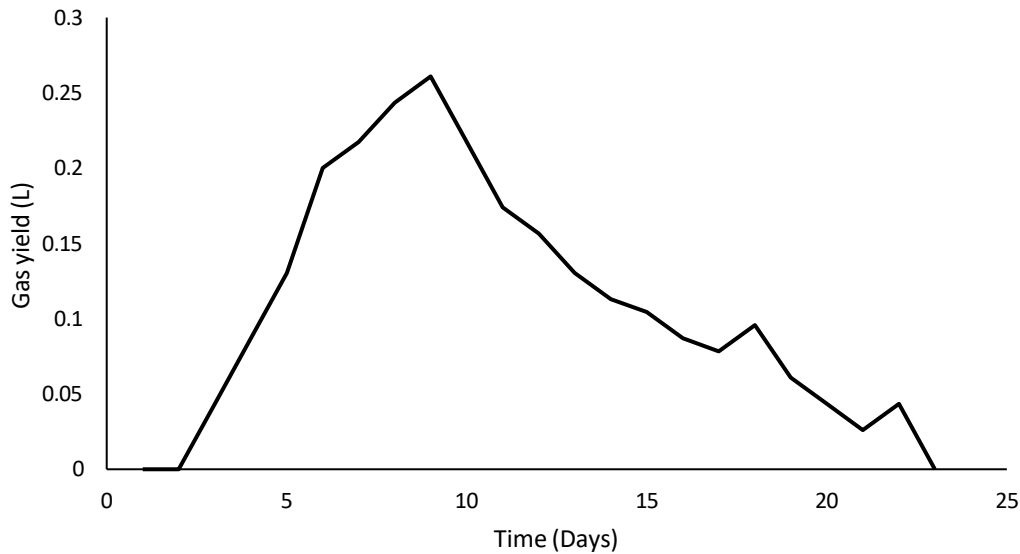


Figure 1: Biogas yield with time

Effect of Temperature on the Gas Yield

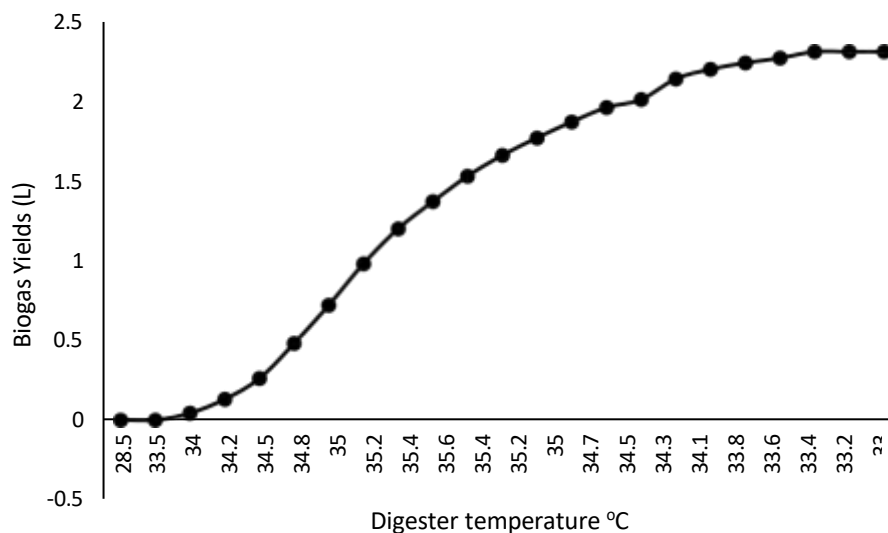


Figure 2: Effect of Temperature on Biogas Yield

There is a positive correlation between the temperature and gas production rate as observed in Figure 2. During the active phase of digestion, the quantity of biogas produced increases as the digester temperature increases from 33.5 °C to 35.6 °C that was observed between the 6th and 10th day of digestion. The peak yield of 0.2609 liters of biogas occurred on day 9 at 35.4 °C, aligning with the 35 – 37 °C optimal temperature range for digestion reported by Gerardi, (2003) and Appels *et al.*, (2008). This peak performance at 34°C can be attributed to enhanced microbial activity within the mesophilic range.

Temperature in this range accelerate hydrolysis and methanogenesis to bring about increase in substrate breakdown and gas production rates. Beyond day 9 gradual decline in yield was observed. This could be attributed to depletion of readily degradable organic matter and the onset of rate-limiting hydrolysis of complex substrate. Therefore, maintaining reactor temperatures within the 35 – 37°C range is critical for optimizing biogas output. These findings support the feasibility of efficient biogas production under monitored mesophilic condition when use in similar agro-climatic region (Matheri *et al.*, 2016).

However, as the digestion progresses and the availability of consumable substrate reduces within the digester system, it affected the gas yield and brought about decline in gas production. Despite the fact that the temperatures still remain within the favorable mesophilic temperature there was a decline. This indicates that temperature was

supportive but isn't the limiting factor; substrate depletion became the dominant determinant of gas output. This trend aligns with the findings of Appels *et al.* (2008), who reported that under stable mesophilic conditions, substrate composition is the primary driver for methane yield in a digester.

Effect of pH on Biogas Yield

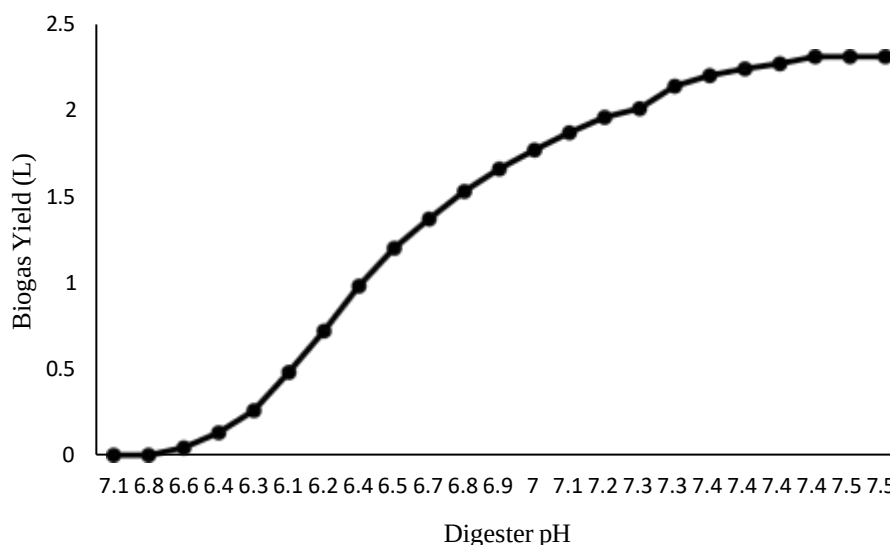


Figure 2: pH against biogas yield from sweet potato peels

The initial increase in biogas volume despite the decline in pH profile for sweet potato peels from 7.1 to 6.1 in the first 6 days was attributed to the rapid activity of acidogenic bacteria, which produce CO_2 and H_2 during hydrolysis of starch. The concurrent accumulation of volatile fatty acids lowered the pH. Subsequent consumption of these acids by methanogens lead to more methane production after 3 days and pH recovery to 7.2 – 7.4. At this stage the fermentative bacteria convert carbohydrates into volatile fatty acids, causing a decline in pH (Yadvika *et al.*, 2004; Appels *et al.*, 2008). That it is despite the decline in pH, gas production was improved significantly during this period, indicating a healthy progression toward methanogenesis. As digestion continued, the pH gradually increases to 6.7–7.3, corresponding with stable pH required for higher gas production.

As shown in figure 3, peak biogas yield coincides with pH values ranging from 6.5 to 7.2 which aligned with the optimal pH range reported for methagenic archaea

(Gerardi, 2003). The gradual increase in pH to above 7.3 toward the end of digestion period suggested the accumulation of bicarbonate and ammonia as by-product of microbial metabolism. When nitrogen containing organic materials such as protein in the substrate is broken down, it releases ammonia NH_3 and ammonium NH_4^+ ions which contributed to the increase in alkalinity and helps increase pH of the slurry.

The generated alkalinity provides buffering capacity that mitigates sudden pH fluctuations. Maintaining a consistent pH between 6.8 and 7.2 throughout methanogenesis is essential for process stability and efficient biogas production (Appels *et al.*, 2008; Ogunlabi and Ogunlabi, 2018).

Biogas Composition of Potato Peels:

The purified biogas sample was analyzed before and after purification as shown in table 1.

Table 1: Composition of Treated Biogas from Potato Peels

S/N	Parameters	Units	Before purification	After purification
1	Oxygen (O ₂)	%	2.1	0.80
2	Carbon Monoxide (CO)	ppm	0.03	0.0
3	Carbon Dioxide (CO ₂)	%	30.2	1.9
4	Nitric Oxide (NO)	ppm	1.73	1.36
5	Nitrogen Dioxide (NO ₂)	ppm	0.96	0.82
6	Ammonia (NH ₃)	ppm	2.5	2.18
7	Sulphur Dioxide (SO ₂)	ppm	0.07	0.03
8	Methane (CH ₄)	%	57.21	84.32
9	Hydrogen Sulphide (H ₂ S)	ppm	1.93	0.04
10	Volatile Organic Compounds (VOC)	ppm	3.27	8.55

Oxygen Content: Biogas should normally contain 0 – 1 % oxygen, for the fact that, oxygen is not produced during anaerobic digestion. The high value of 2.1% recorded in Table 1 did not originate from the digester; rather, it was as a result of air contamination during sampling or micro-aeration. Possible causes include:

1. Sampling the gas while the storage bag was not completely filled
2. Analyzer probe exposed to ambient air before testing
3. Minor leakage in tubing or fittings
4. Purification system introducing air during operation

Such contamination is commonly observed in biogas sampling. Arrhenius et al., (2019) reported that gas bag permeability, tube leakages, and improper purging can introduce atmospheric oxygen into the sample. Similarly, practical guidelines for biogas analysis recommend an air-tight sampling procedures to prevent such errors (Ohio Lumex, 2023). Although the measured oxygen does not affect the methane content obtained in this study, it emphasizes the need for careful sampling protocols to avoid dilution or contamination, in order to obtained accurate biogas characterization.

Carbon Monoxide Content: The CO level recorded in the treated biogas was low (0.03 ppm) as shown in Table 1, indicating that no incomplete combustion or pyrolysis occurred inside the digester. This aligns with expectations of properly operated anaerobic systems, where carbon monoxide is typically present only as a trace gas (Flotats and Bonmatí, 2006). According to International Energy Agency (IEA) (2020), values below 50 ppm are generally considered safe and do not pose any health or operational

risks. The low CO concentration confirms that the digestion process proceeded under strictly anaerobic and non-combustive conditions, and that the purification process did not introduce CO or other hazardous gases.

Carbon Dioxide Content: Raw biogas typically contains 25–45 % carbon dioxide, which lowers its calorific value. After treatment of the produced biogas, it was shown in Table 1 that CO₂ level was 1.9 % from initial value of 30.2 %, an indication that the purification method adopted achieved an excellent reduction of CO₂ from the raw biogas. This finding agrees with Ryckebosch & Vervaeren (2011), who reported that CO₂ can be reduced to below 5% using chemical absorption, water scrubbing, or pressure swing adsorption (PSA). The success in lowering the CO₂ content in the biogas contributed greatly to the increase in methane concentration recorded.

Nitrogen Oxides (NO, NO₂, NO_x): The nitrogen oxides recorded in the treated biogas were also in decrease (NO = 1.36 ppm, NO₂ = 0.82 ppm, NO_x = 2.18 ppm), indicating minimal contamination from external sources. Anaerobic digestion itself does not produce nitrogen oxides, as these gases are typically formed during combustion or high-temperature oxidation processes (Flotats et al., 2006). Their presence in the gas sample is therefore likely due to minor exposure to ambient air during sampling or handling, rather than being a product of microbial digestion. Such low concentrations are consistent with safe, high-quality biogas.

Methane Content: Methane is the major energy-yielding component of biogas and it determines the fuel quality and flammability of the gas. As shown in Table 1, the purified

biogas produced from potato peels contained 84.32 % methane after purification. This is significantly higher than the normal range of 50–70% reported for raw biogas in some literatures (Drouillon and Vervaeren, 2011). This high value indicates that the purification method applied was effective in removing CO₂, H₂S, and other non-combustible gases. According to Angelidaki and Sanders (2004), purified biogas can reach methane levels of 82–98 %, which agrees with the value obtained in this study. Such quality of methane may be very suitable for cooking, heating, and electricity generation, and can serve as a substitute to upgraded natural gas.

Hydrogen Sulphide Content: Hydrogen sulphide is a corrosive and toxic gas that must be removed from biogas before use. Raw biogas often contains 50–10,000 ppm of H₂S depending on the substrate. Table 1 shows that there is a very low H₂S concentration of 0.04 ppm recorded in this study which indicates that almost all sulphur compounds are completely removed. Muñoz et al. (2015) recommended that H₂S levels below 100 ppm are safe for engines and burners; hence the value obtained is far below the safety threshold. This means the purified biogas will have minimal corrosion effect when in use or may produce less offensive odor.

Sulphur Dioxide Content: The Sulphur dioxide content of the treated biogas was 0.03 ppm, indicating that almost all Sulphur-bearing compounds were successfully removed during purification. Such a concentration confirms the high quality of the biogas and ensures that it will not cause corrosion in engines or release unpleasant odors during use. This aligns with best practices for biogas purification, where SO₂ levels are ideally kept below 100 ppm to ensure safety and usability (Muñoz et al., 2015; Drouillon, and Vervaeren, 2011).

Volatile Organic Compounds: The VOC content in the treated biogas was low at 8.3 ppm, indicating that only minor traces of organic vapors remained after purification. VOC levels below 10 ppm are typical for well-treated biogas and do not significantly affect its fuel quality or performance. This demonstrates that the purification process effectively removed volatile contaminants, contributing to clean, and high-quality biogas suitable for use in cooking, heating, or electricity generation (Ryckebosch, Drouillon, & Vervaeren, 2011).

CONCLUSION

This study demonstrates that biogas production from sweet potato peels is a temperature dependent substrate with the maximum yield achieved at 35.4°C on day 9. The result affirms the established literature identifying 35 -37°C as the optimum for mesophilic anaerobic digestion. The reduced retention time observed here could be attributed to preliminary steps of size reduction, soaking and co-digestion with cow dung. These measures enhance substrate bioavailability and inoculate the mixture with active methanogens needed in substrate conversion, which brings about accelerated hydrolysis step that possibly could be rate limiting step of the production.

Processing steps like size reduction, soaking and mixing with cow dung inoculum boosted microbial activity and sustained biogas production for 25 days. Optimal mesophilic temperatures and pH levels supported stable digestion and gas yield. The biogas from potato peels showed a high methane content (84.32%) after purification, with minimal contaminants, making it suitable for cooking and electricity generation. These findings highlight the potential of agricultural waste to energy solutions, supporting small scale biogas systems for rural communities and reducing environmental pollution. Simple purification methods also improved the biogas quality and system efficiency as well.

RECOMMENDATIONS

Based on the results and observations from this study, the following recommendations are made:

1. Different pretreatment method be tried on the substrate to compare the biodegradability efficiency and enhancement of methane yield.
2. Co-digestion of potato peels with another agricultural waste, to possibly achieve a more balanced C/N ratio is encouraged.
3. The use of continuous stirred-tank digester or semi-continuous system is recommended to maintain steady agitation, reduce stratification, and to enhance overall microbial activity.
4. Future work can incorporate additional purification stages, such as silica gel drying or activated carbon filters.
5. Government and community stakeholders should promote awareness programs that will encourage the adoption of biogas technology as a sustainable alternative to firewood and fossil fuels, thereby reducing deforestation and greenhouse gas emissions.

6. Long-term assessment should be conducted to evaluate environmental impacts such as reduction in waste accumulation, mitigation of methane emissions, and improvement in sanitation practices.

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EVALUATION OF CARBONATED PROBIOTIC HIBISCUS SODA BEVERAGES USING GINGER BUG

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ABSTRACT

The benefits of probiotic beverages they serve as micro-biomes for normal metabolic activity. This study investigated the mineral composition, microbial and sensory properties of carbonated probiotic hibiscus soda beverages produced using ginger bug as a natural source of carbonation. Standard procedures were used to prepare the hibiscus extract, activate the ginger bug, and ferment the beverage. The resulting samples were analyzed for mineral composition (calcium, iron, and potassium) and subjected to sensory evaluation by a trained panel. The data obtained were statistically analyzed using analysis of variance (ANOVA). Calcium levels ranged from 14.23-17.27 mg/100 g, iron from 0.38-0.45 mg/100 g, and potassium from 29.09–30.84 mg/100 g, with significant differences ($P < 0.05$) among samples. These values confirm the nutritional relevance of the beverage, particularly in supporting bone health, oxygen transport, and electrolyte balance. Sensory evaluation indicated high consumer acceptability on a nine-point hedonic scale, with mean scores for color (7.50-8.00), taste (7.20-7.85), flavor (6.75-7.60), mouth feel (7.35-7.55), appearance (7.55–8.00), and overall acceptability (7.05-7.80). Statistically significant differences ($P > 0.05$) were observed among samples, the microbial result range from 1.0×10^3 to 1.4×10^3 and 1.0×10^3 to 1.1×10^3 respectively, indicating consistent quality and palatability. The carbonated probiotic hibiscus soda produced with ginger bug demonstrated both nutritional and sensory appeal, offering a functional alternative to conventional carbonated soft drinks. The findings suggest that the beverage holds promise for consumer marketability, health promotion, and the functional beverage industry.

Keywords: mineral, microbial sensory, probiotic, Hibiscus, ginger

INTRODUCTION

Probiotics carbonated beverages have become a popular choice for many consumers worldwide, with a growing interest in functional drinks that not only provide refreshment but also offer health benefits (Saxelinet *al.*, 2013). Probiotic beverages, particularly those containing live microorganisms that provide health benefits when consumed in adequate amounts, have gained significant attention due to their potential to improve gut health and enhance the immune system. Hibiscus, a flowering plant known for its vibrant color and tart flavor, has been used traditionally for its medicinal properties, including its ability to lower blood pressure and support heart health Hopkins (et al., 2013)

In recent years, there has been a surge in consumer interest for functional beverages, particularly those offering health benefits beyond basic nutrition. Among these, probiotic drinks have gained significant attention for their positive effects on gut health, immunity, and overall well-being (Saxelinet *al.*, 2013). Probiotics, which are live microorganisms that confer health benefits to the host when consumed in adequate amounts, have been incorporated into a variety of food and beverage products. These beneficial organisms primarily species of *Lactobacillus*, *Bifidobacterium*, and certain yeasts such as

Saccharomyces boulardii have been widely incorporated into a variety of food and beverage products, including yogurt, fermented milk drinks, dietary supplements, and functional foods.. Carbonated beverages, a popular category of drinks, are often artificially carbonated with carbon dioxide (CO₂) to provide effervescence and refreshing qualities. However, there is a growing trend toward exploring natural carbonation methods, such as using ginger bug, a fermented mixture of ginger, sugar, and water, to create naturally carbonated beverages (Yap *et al.*, 2015).

This study explores the potential of creating a carbonated probiotic hibiscus soda using ginger bug as a natural source of carbonation. The sensory properties of this beverage, including its flavor, appearance, texture, and overall acceptability, are key to determining its potential success in the market.

A ginger bug is a natural, homemade starter culture that uses the process of fermentation to create a base for homemade probiotic drinks like ginger ale or other fizzy, fermented beverages. It is made from a mixture of fresh ginger, sugar, and water, which encourages the growth of wild yeasts and bacteria, providing natural carbonation and beneficial probiotics.

The benefits of probiotics and natural fermentation methods are well-documented; there is limited research on the sensory evaluation and consumer acceptance of carbonated probiotic hibiscus soda produced using ginger bug as the natural carbonation source. Hibiscus has been explored for its health benefits, but its application in a carbonated probiotic beverage, especially one using natural carbonation, remains under-researched. It is unclear how the carbonation process through ginger bug affects the sensory characteristics of the hibiscus soda, such as its taste, mouthfeel, and overall consumer preference. Given the growing consumer demand for functional and naturally carbonated drinks, it is crucial to investigate how these factors interact and how they influence consumer acceptance.

MATERIALS AND METHODS

Fresh ginger, hibiscus, sugar, honey, water kefir, probiotic powder, bottle etc.

Sample Collection: Fresh ginger, hibiscus, honey, sugar, water kefir, probiotic, and bottles used for this study were purchased from Modern Market, Bida, Niger State.

The AAS used for chemical analysis were of analytical grade. The mineral analysis (Calcium, Iron and potassium) was carried out in triplicates using standard AOAC (2023) Sensory evaluation was carried out using a 9-point hedonic scale. The results obtained were subjected to one way ANOVA and means were separated using Duncan Multiple Range Test (DMRT)

Table 1: Mineral Composition (mg/100g) of Carbonated Probiotic Hibiscus Soda Using Ginger Bug as a Natural Source of Carbonation.

Samples	Calcium (mg/100g)	Iron (mg/100g)	Potassium (mg/100g)
A	14.23 ^b ±0.02	0.44 ^a ±0.00	29.09 ^c ±0.04
B	10.84 ^c ±0.23	0.38 ^b ±0.02	30.84 ^a ±0.04
C	17.27 ^a ±0.07	0.45 ^a ±0.03	30.26 ^b ±0.05

Values are means ± standard deviation of duplicate determination. Values in the same column with different superscripts are significantly different (p<0.05). A = 48 Hours fermentation time, B = 72 Hours fermentation time, C = 96 Hours fermentation time

Table 2: Microbial evaluation of Carbonated Probiotic Hibiscus Soda Using Ginger Bug as a Natural Source of Carbonation.

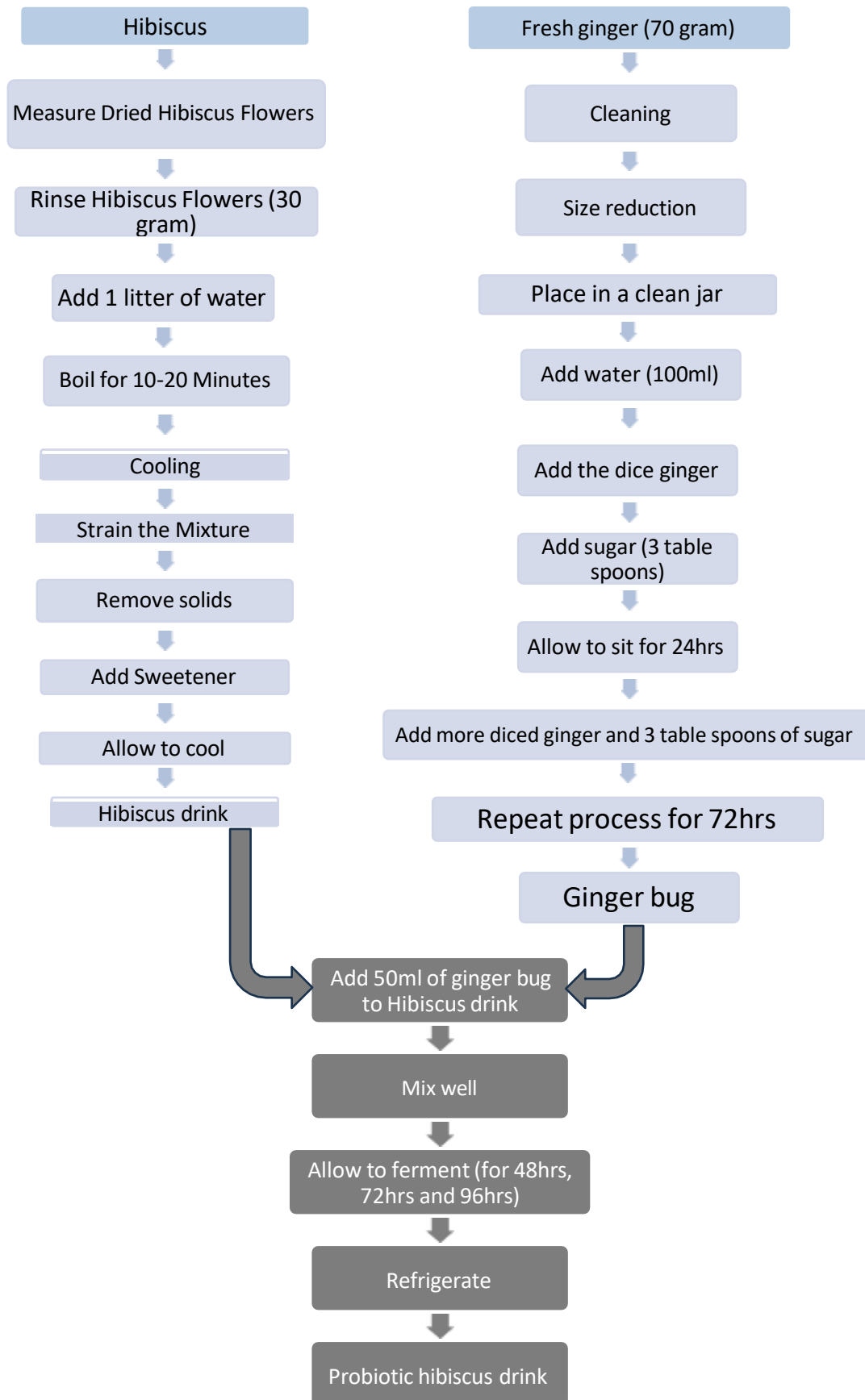
Sample	Total plate count cfu/mL	Fungi count cfu/ml
A	1.0 x 10 ³ ± 0.0 ^b	NP
B	1.2 x 10 ³ ± 0.00 ^a	1.0 x 10 ³ ± 0.09
C	1.4 x 10 ³ ± 0.10 ^a	1.1 x 10 ³ ± 0.50 ^a

Values are means ± standard deviation of duplicate determination. Values in the same column with different superscripts are significantly different (p < 0.05). A = 48 Hours fermentation time, B = 72 Hours fermentation time, C = 96 Hours fermentation time. NA = Not present

Table 3: Sensory evaluation of Carbonated Probiotic Hibiscus Soda Using Ginger Bug as a Natural Source of Carbonation.

Samples	Colour	Taste	Flavor	Mouthfeel	Appearance	Overall acceptability
A	8.00 ^a ±1.08	7.85 ^a ±1.04	7.60 ^a ±1.10	7.55 ^a ±1.10	7.85 ^a ±1.18	7.80 ^a ±0.77
B	7.75 ^a ±1.64	7.50 ^a ±1.57	6.75 ^a ±1.59	7.35 ^a ±2.01	8.00 ^a ±1.21	7.05 ^b ±0.95
C	7.50 ^a ±1.70	7.20 ^a ±1.36	7.30 ^a ±1.45	7.45 ^a ±1.43	7.55 ^a ±1.10	7.10 ^b ±0.72

Values are means ± standard deviation of duplicate determination. Values in the same column with different superscripts are significantly different (p < 0.05). A = 48 Hours fermentation time, B = 72 Hours fermentation time, C = 96 Hours fermentation time



Source: (Adeyemi *et al.*, 2022)

Fig: 1 Modified flow chart showing the preparation of hibiscus drinks and fresh ginger

DISCUSSION

The mineral composition of carbonated probiotic hibiscus soda using ginger bug as a natural source of carbonation was investigated. The calcium, iron, and potassium contents of the formulated samples were determined, and significant differences ($P < 0.05$) were observed among them. Mineral composition is an important parameter in functional beverages, as it contributes not only to nutritional quality but also to physiological functions such as bone health, oxygen transport, and electrolyte balance (Oludemiet *et al.*, 2023). The calcium content of the samples ranged from 14.23–17.27 mg/100 g, with sample A recording the least value and sample C the highest. The increase in calcium levels in sample C may be attributed to the higher concentration of hibiscus extract and the fermentation activities of the ginger bug, which may have enhanced mineral solubilization. This trend is similar to the report of Abubakar *et al.* (2022), who observed an increase in calcium levels in fermented sorghum-based beverages. However, the values recorded in this study were slightly lower than those reported by Adeleye and Osundahunsi (2023) for calcium-rich fortified probiotic drinks, suggesting that dilution during preparation might have influenced the final concentration.

The iron content of the samples ranged from 0.38–0.45 mg/100 g, with sample B having the least value and sample C the highest. There was no significant difference ($P > 0.05$) between sample A and C. Iron is an essential mineral for hemoglobin formation and energy metabolism. The relatively low levels observed in this study align with findings by Ezeochaet *et al.* (2023), who also reported reduced iron content in hibiscus-based beverages compared to the raw calyces. This reduction may be due to the solubility and binding of iron during fermentation. Conversely, Ibrahim *et al.* (2022) reported higher iron retention in spontaneously fermented sorghum beverages, suggesting that the type of fermentation starter (ginger bug vs. microbial inoculant) could influence mineral preservation. The potassium content of the samples ranged from 29.09–30.84 mg/100 g, with sample A recording the least and sample B the highest value. Potassium is vital for electrolyte balance and cardiovascular health, and hibiscus is widely reported as a rich source of this mineral. The significant differences ($P < 0.05$) observed among the samples may be due to variations in fermentation activity and raw material composition. The findings are in agreement with those of Mahadevan *et al.* (2019), who

reported potassium as the predominant mineral in hibiscus drinks. However, the potassium levels recorded in this study were lower than those reported by Adeyemi *et al.* (2022) for hibiscus-based probiotic beverages, possibly due to differences in ingredient concentration and fermentation conditions.

Overall, the results suggest that probiotic hibiscus soda produced with ginger bug retained appreciable levels of calcium, iron, and potassium, making it a functional beverage with nutritional relevance. While supporting studies (Mahadevan *et al.*, 2019; Abubakar *et al.*, 2022) confirm hibiscus drinks as mineral-rich, opposing findings (Ezeochaet *et al.*, 2023; Adeleye and Osundahunsi, 2023) highlight possible reductions in mineral retention due to dilution or fermentation type. This indicates that further optimization in formulation and fermentation control could enhance mineral bioavailability and overall nutritional value.

The microbial result also revealed statistically that 72 hours and 96 hours of fermentation of the hibiscus beverages matrix significantly ($p < 0.05$) higher than 48 hours of fermentation with values ranges from 1.0×10^3 – 1.4×10^3 cfu/ml. These differences could be associated to handling process and variation exist in the fermentation time as Izah and Ohimaih (2016) reported that some microbes have a short-time proliferation in favourable condition. The fungi count recorded less count in 72hrs and 96hrs fermentation of the hibiscus beverages. However, 48hrs of the fermentation indicate fungi growth. It was observed that the result shows safe level of the beverage consumption for way exceeding the WHO level within specific ranges in different food samples for microorganism.

The sensory evaluation of carbonated probiotic hibiscus soda using ginger bug as a natural source of carbonation was carried out to determine consumer acceptance in terms of colour, taste, flavour, mouthfeel, appearance, and overall acceptability. Results showed that there were no significant differences ($P > 0.05$) among the samples for all sensory attributes. Sensory evaluation is a key factor in determining market success of functional beverages, as consumers often judge product quality by sensory appeal rather than nutritional value (Small and Prescott, 2005). The colour scores ranged from 7.50–8.00, with sample C recording the least score and sample A the

highest. The high colour ratings across all samples confirm hibiscus as a rich natural source of anthocyanins, responsible for its deep red colour. This finding agrees with Mahadevan *et al.* (2019), who reported strong consumer preference for hibiscus-based drinks due to their attractive pigmentation. Similar trends were observed by Abubakar *et al.* (2022) in hibiscus-sorghum probiotic beverages. The taste attribute ranged from 7.20–7.85, with sample C having the lowest score and sample A the highest. The relatively high taste scores across samples suggest good flavour balance between the hibiscus base, sweeteners, and carbonation from the ginger bug. This agrees with Adeyemi *et al.* (2022), who noted that controlled fermentation improved taste quality of hibiscus probiotic beverages. However, Ezeochaet *et al.* (2023) reported that excessive fermentation could lead to increased sourness, thereby lowering taste acceptance highlighting the need for careful fermentation control.

The flavour scores ranged from 6.75–7.60, with sample B having the least and sample A the highest value. Though not significantly different ($P>0.05$), the slight variations may be linked to differences in fermentation activity and residual ginger compounds. Similar flavour improvements from ginger-based fermentation were reported by Ibrahim *et al.* (2022), who found that bioactive compounds from ginger enhanced aroma profiles in fermented drinks.

Mouth feels scores ranged from 7.35–7.55, with sample B recording the lowest and sample A the highest. The consistency in scores indicates that carbonation produced by the ginger bug was uniform across all samples. This is consistent with the findings of Oludemiet *et al.* (2023), who emphasized that carbonation enhances sensory perception of mouth feel in probiotic sodas.

The appearance scores ranged from 7.55–8.00, with sample C having the lowest and sample B the highest. The high appearance ratings align with consumer expectations of hibiscus drinks as visually appealing. This agrees with Mahadevan *et al.* (2019), who noted that bright red hues positively influence consumer preferences in hibiscus beverages. Overall acceptability scores ranged from 7.05–7.80, with sample B recording the least and sample A the highest. The high acceptability across all samples suggests that carbonated probiotic hibiscus soda made with ginger bug is well-received, showing potential for consumer marketability. These findings agree with Adeyemi *et al.*

(2022), who reported positive consumer acceptance of hibiscus probiotic beverages, but differ slightly from Ezeochaet *et al.* (2023), who observed moderate consumer response when sourness was pronounced. In general, the results demonstrate that all samples were well accepted by the panelists, showing no significant differences among sensory attributes. This indicates that ginger bug carbonation successfully produced a probiotic hibiscus soda with appealing sensory qualities comparable to commercial soft drinks but with added health benefits.

CONCLUSION

This study investigated the mineral composition, microbial and sensory properties of carbonated probiotic hibiscus soda using ginger bug as a natural source of carbonation. The findings revealed that the beverage contained appreciable amounts of essential minerals such as calcium, iron, and potassium, which are important for bone development, oxygen transport, and electrolyte balance. Although variations were observed among samples, the values obtained indicate that the product can contribute to dietary mineral intake. However, the count of microbial recorded were low. The sensory evaluation showed that all samples were well accepted by panelists in terms of color, taste, flavor, mouth feel, appearance, and overall acceptability, with no significant differences ($P>0.05$) among the samples. This suggests that ginger bug fermentation provided consistent carbonation and improved palatability, making the probiotic hibiscus soda comparable in sensory appeal to conventional carbonated soft drinks while offering additional health benefits. The study therefore concludes that carbonated probiotic hibiscus soda produced with ginger bug is not only nutritionally relevant but also acceptable to consumers. It represents a promising functional beverage that can promote health, enhance dietary diversity, and serve as a natural alternative to sugar-laden commercial soft drinks.

RECOMMENDATIONS

Based on the findings of this research, the following recommendations are made:

- i. The production of carbonated probiotic hibiscus soda using ginger bug should be scaled up for commercial purposes, as it combines nutritional benefits with high consumer acceptance.
- ii. Further research should be carried out on the storage stability, and shelf-life of the probiotic hibiscus soda

under different preservation and packaging conditions.

- iii. Public health campaigns and nutrition education should promote hibiscus-based probiotic beverages as healthier alternatives to conventional soft drinks, especially among young consumers who are heavy soda drinkers.
- iv. Food industries and government agencies should support local innovations in probiotic beverages through funding, training, and policy incentives to boost small-scale production and encourage the use of natural fermentation starters like ginger bug.

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COMPARATIVE MICROBIAL ASSESSMENT OF HEALTH FACILITY AND NON-HEALTH FACILITY AIR-CONDITIONING UNITS IN CALABAR, NIGERIA

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ABSTRACT

Air-conditioning units in tropical regions create indoor environments which serve as breeding grounds for microbial pathogens that increase chances of disease spread in healthcare settings. This study compared microbial contamination in AC units from health and non-health facilities in Calabar, Nigeria. A cross-sectional study design was adopted and a sample size of 115 AC units (67 health, 48 non-health) was used. Swabs from filters, coils, and pans were cultured on selective media. Isolates were identified biochemically and morphologically. Data were analyzed using chi-square tests ($P < 0.05$). Result shows that contamination affected 40% (46/115) of units, with 41.8% in health vs. 37.5% in non-health facilities ($P = 0.60$). Bacteria predominated (39 isolates) were *Staphylococcus aureus* (43.6%), *Pseudomonas aeruginosa*, *Klebsiella* spp. (23.1% each), *Legionella* spp. (7.7%) and *Bacillus* spp. (2.6%). While the fungi (7 isolates) included, *Aspergillus flavus* (57.1%) and *Penicillium* spp. (42.9%). Co-contamination occurred in 5.2%. Health facilities showed higher bacterial loads, but differences were non-significant ($P > 0.05$). The study concludes that AC units in Calabar harbor pathogenic microbes, with health facilities at marginally higher risk. Thus, routine maintenance is crucial to prevent bioaerosol-related infections in tropical settings.

Keywords: Air-conditioning; Microbial contamination; bacteria; fungi; Nigeria

INTRODUCTION

In tropical regions like Nigeria, air-conditioning (AC) systems are essential for indoor comfort but can accumulate moisture and dust, fostering microbial biofilms (Uzuegbunam et al., 2018). These pollutants, notably bacteria and fungi may become aerosolized and spread throughout the indoor environment through circulating air currents (Hussain et al., 2022). Continuous exposure to contaminated air can raise the risk of respiratory tract infections, allergic responses, asthma exacerbations, and other health issues, especially among immunocompromised individuals, patients, healthcare professionals, and inhabitants of poorly ventilated facilities.

In healthcare settings, the presence of harmful microorganisms in AC units may further contribute to the spread of healthcare-associated diseases and degrade indoor air quality (Hussain et al., 2022; Gorlach et al., 2025). Health facilities, with high patient turnover, are particularly vulnerable to nosocomial pathogens, while non-health settings (e.g., offices) face environmental exposures (Gorlach et al., 2025). Common isolates include *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and *Aspergillus* spp., linked to pneumonia and aspergillosis (Wijedoru et al., 2017). In humid Calabar, perennial

moisture exacerbates contamination (Olukosi et al., 2018). Nigerian studies report high bacterial loads in ACs, with *Bacillus* and *Aspergillus* prevalent. Comparative data are limited, yet vital for infection control amid rising HAIs (Otu-Bassey et al., 2021). This study compares microbial profiles in health vs. non-health AC units, hypothesizing higher pathogenic diversity in health settings due to bioaerosol exposure. Findings inform tropical biomedicine strategies for safer indoor air.

METHODOLOGY

Study design and population: Cross-sectional survey in Calabar, Nigeria (April–August 2023). Sampled 115 AC units: 67 from health facilities (hospitals/clinics), 48 from non-health facilities (offices/hotels). Oral consent and approval were sought and obtained from facility managers.

Sampling and culture: Sterile swab samples were collected from the filters, coils, and drain pans of the air-conditioning units and subsequently transported in peptone water for microbiological analysis. Inoculated on nutrient/MacConkey agar (bacteria, 37°C/24-48h) and Sabouraud agar (fungi, 25°C/3-7d).

Identification:

Bacteria: Gram stain, biochemical tests (catalase, coagulase, etc.).

Fungi: Lactophenol blue microscopy.

Statistical analysis: Frequencies, percentages; chi-square for comparisons (SPSS v25, $p < 0.05$).

RESULTS AND DISCUSSION

Microbial contamination was detected in 46/115 (40.0%) units. Health facilities had 28/67 (41.8%) contaminated vs. 18/48 (37.5%) in non-health ($\chi^2 = 0.28$, $p = 0.60$). Bacteria dominated (39 units), fungi in 7, co-contamination in 6 (Table 1).

Table 1: Distribution and contamination status of air-conditioning units by facility type

Facility Type	Total Units	Contaminated n (%)	Bacteria n (%)	Fungi n (%)	Co-contamination n (%)
Health	67	28 (41.8)	24 (35.8)	4 (6.0)	4 (6.0)
Non-Health	48	18 (37.5)	15 (31.3)	3 (6.3)	2 (4.2)
Total	115	46 (40.0)	39 (33.9)	7 (6.1)	6 (5.2)

Table 1 illustrates overall contamination, with health facilities showing marginally higher rates, though non-significant ($p = 0.60$). Bacterial dominance suggests moisture-driven growth.

Table 2: Distribution of bacterial isolates by facility type

Species	Health n (%)	Non-Health n (%)	Total n (%)
<i>S. aureus</i>	11 (44.0)	6 (42.9)	17 (43.6)
<i>P. aeruginosa</i>	6 (24.0)	3 (21.4)	9 (23.1)
<i>Legionella</i> spp.	2 (8.0)	1 (7.1)	3 (7.7)
<i>Bacillus</i> spp.	1 (4.0)	0 (0.0)	1 (2.6)
<i>Klebsiella</i> spp.	5 (20.0)	4 (28.6)	9 (23.1)
Total	25 (100)	14 (100)	39 (100)

Bacterial distribution was similar ($\chi^2 = 1.42$, $p = 0.84$), with *S. aureus* prevalent, indicating human-derived contamination.

Table 3: Distribution of fungal isolates by facility type

Species	Health n (%)	Non-Health n (%)	Total n (%)
<i>Penicillium</i> spp.	2 (50.0)	1 (33.3)	3 (42.9)
<i>A. flavus</i>	2 (50.0)	2 (66.7)	4 (57.1)
Total	4 (100)	3 (100)	7 (100)

Fungal patterns were comparable ($\chi^2 = 0.29$, $p = 0.59$), with *A. flavus* dominant, a tropical allergen.

Table 4: Comparative prevalence of contamination types

Type	Health n (%)	Non-Health n (%)	χ^2 (p)
Bacterial Only	20 (71.4)	13 (72.2)	0.004 (0.95)
Fungal Only	0 (0.0)	1 (5.6)	1.62 (0.20)
Co-contamination	4 (14.3)	2 (11.1)	0.09 (0.76)
Uncontaminated	39 (58.2)	30 (62.5)	0.28 (0.60)
Total Contaminated	28 (41.8)	18 (37.5)	-

Contamination types showed no differences, emphasizing bacterial focus for interventions.

Contamination rates (40%) align with tropical studies (Upula et al., 2023). Non-significant differences suggest universal risks, but health facilities' higher bacterial loads imply patient-derived sources. Pathogens like *S. aureus*

and *P. aeruginosa* pose HAI threats (Upula et al., 2023; Out-Bassey et al., 2021). Fungi, though low, warrant attention in immunocompromised settings (Kohler et al., 2017). Limitations: culture-based methods may

underestimate; future PCR needed. Tropical humidity exacerbates issues; regular disinfection recommended. Comparatively, within Africa, this finding of 40% overall contamination and bacterial dominance are lower than some regional reports. For instance, a previous study in Calabar, Nigeria, found 100% bacterial contamination in AC filters from hotels, offices, and hospitals, with *Bacillus* spp. (50.8%) and *Aspergillus niger* (60%) prevalent, highlighting potentially higher risks in diverse settings (Otu-Bassey et al., 2021). In Ethiopia's Jimma Medical Center, indoor air microbial loads reached 466 CFU/m³ in wards, dominated by *Staphylococcus* and *Bacillus*, exceeding this qualitative assessment and underscoring hospital-specific burdens (Belay et al., 2024). Harar private clinics in Ethiopia reported fungal loads of 351-401 CFU/m³, higher than this low fungal prevalence (6.1%), possibly due to differences in sampling methods or ventilation (Temesgen et al., 2024). South African hospital studies identified the genera *Bacillus*, *Kocuria*, and *Staphylococcus* with counts up to 6×10⁴ CFU/m³ in kitchens and wards, aligning with this bacterial focus but indicating seasonal or occupancy influences (Setlhare et al., 2024). Across Africa, including Benin City, Nigeria, and Morocco's Agadir hospital (fungal counts 29-176 CFU/m³), contamination often exceeds acceptable limits in healthcare, driven by poor maintenance and high humidity. This study's lower rates may reflect improved awareness, but emphasize the need for standardized protocols continent-wide (Oulkheir et al., 2021; Ogefere et al., 2025). Globally, these results mirror patterns in Asia and beyond, where HVAC systems harbor antibiotic-resistant bacteria, with reviews stressing maintenance to curb risks. In Chengdu, China, household bacterial counts reached 12,296 CFU/cm² in water sinks, dominated by *Methylobacterium* and *Bacillus*, far higher than this prevalence, likely due to sampling intensity (Sun et al., 2024). Japanese studies on 17 houses revealed *Pseudomonas* and *Staphylococcus* as top genera on filters, similar to our *S. aureus* dominance, with Gram-negative bacteria prevalent (Watanabe et al., 2022). A scoping review indicated lower microbial loads in well-managed AC areas globally, but increased infections if neglected, as in this non-significant health vs. non-health differences (Wu et al., 2021). Comprehensive reviews highlight sources like coils and filters fostering biofilms, with global risks amplified in humid tropics. Compared to temperate regions (e.g., Europe, USA), where seasonal variations reduce year-round growth, tropical Africa faces perennial

challenges, necessitating adapted strategies like HEPA filters seen in Italian hospitals (70-90% reduction) (Bakker et al., 2020; Kravchenko et al., 2023).

CONCLUSION

This study concludes that AC units in Calabar harbor microbes, with health facilities at elevated risk. Enhanced maintenance is vital for tropical infection control.

RECOMMENDATION

Healthcare facilities should establish regular cleaning and disinfection procedures for all AC system components which include filters and coils and ducts to decrease microbial buildup and biofilm development. Additionally, healthcare facilities should include AC maintenance activities into their current IPC programs while focusing on important locations which include wards and intensive care units and operating theatres.

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THE VEGETATIVE AND PHYSIOLOGICAL EFFECT OF NPK FERTILIZER CONCENTRATIONS ON THE SEEDLINGS OF TOMATO (*Lycopersicon esculentum* Mill)

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ABSTRACT

This study looked at the morphological characteristics and physiological behaviour of tomato (*Lycopersicon esculentum* Mill.) seedling to five different concentrations of 3.00g, 5.00g, 7.00g, 8.00g and 10.00g per 2kg of soil and control in a randomized complete blocks design made up of ten replicates. Seeds were sown in a plastic pot and left for ten days to germinate before they were transplanted to polythene bags. Varying concentrations of NPK fertilizer (3.00g, 5.00g, 7.00g, 8.00g, and 10.00g per 2kg of soil) were applied. Number of leaflets, leaflets with lesions, and number of dead leaves were counted for twenty days after NPK fertilizer application. The findings revealed that higher concentration (8.00g and 10.00g) had unusual growth while 5.00g and 7.00g concentrations had more leaflets than the control. Moreover, increase in NPK fertilizer concentration resulted in the rise of leaves with lesions and dead leaflets. 10.00g had the highest number of leaves with lesions and increase in leaflets death. This result revealed that 5.00g and 7.00g per 2kg of soil is ideal for proper plant growth. Meanwhile, undue concentration leads to tissue destruction and physiological strain. An ideal NPK fertilizer application and carrying out soil test to ascertain nutritional composition is recommended.

Keywords: Dead Leaves, Leaflets Number, Lesion, NPK fertilizer, Tomato.

INTRODUCTION

The tomato, or *Lycopersicon esculentum* Mill. is a basic fruit and vegetable that has become increasingly popular over the past century (Umeohia & Olapade, 2024) and is acknowledged as one of the most significant cash and industrial crops worldwide (Massrie & Zewdie, 2025). It is a delicate, sensitive to compression fruit that is categorized as a berry in botany and is a member of the Solanaceae family (Alhaji *et al.*, 2025).

Even though tomatoes are never ending plant, some species are grown as annual crop in some parts of the world (Alhaji *et al.*, 2025). Beside potatoes, tomato is the second most important vegetable plant (Almekinders & Nuijten, 2026). Tomato is an essential ingredient in many indigenous foods and an important part of Nigerian nourishment in both rural and urban locations because it provides essential vitamins and minerals (Chukwuma *et al.*, 2026). It is rich in water soluble vitamins and minerals, essential amino acids, carbohydrates, and dietary fibre, less fat and calories, and a major source of vitamins A, B, C, iron, phosphorus, protein, edible oil, and lycopene (Singh *et al.*, 2025). Also, tomato can be manufactured into enhanced products as such juices, paste, puree, ketchup, and canned goods, or it can be eaten raw in salads, sauces, soups and meat and fish foods (Sen *et al.*, 2022). Tomato consumed everyday provides the body with elements such

as lycopene, carotene, and vitamins that reduces the risk of cardiovascular illness and cancer (Balali *et al.*, 2025). Furthermore, tomatoes have antioxidant properties that help with bone metabolism, asthma, cataracts and lessen the risk of prostate and breast cancer (Fagbohun *et al.*, 2023). Tomato is 18% of Nigeria's daily consumption (Olaniran *et al.*, 2022).

It is now regarded as an important cash and industrial crop in many parts of the world (Albertsen *et al.*, 2026). Tomato yield and consumption in the world have increase substantially in the last 25 years (Gomez *et al.*, 2026). About 3.9 million hectares of land yielded about 105 million tons of fresh fruit (Monday *et al.*, 2024). Prior to 1990, Nigeria supposedly produced 6 million tons of tomatoes yearly, which makes it the second largest producer in Africa after Egypt and ranked 13th in the world (Ambreen *et al.*, 2025). In Nigeria, tomatoes are grown in a diverse agro- ecological zones, which are semi-arid/arid in the northern part, humid in the southern part, and sub-humid in the middle belt (Idris *et al.*, 2025). It is mostly grown in the country's northern regions, at temperatures between 25 and 34 °C and latitudes between 7.5 °N and 13 °N. Nigeria is said to produce enormous amounts of fruits and vegetables, yet estimates of the nation's yearly production are sometimes given with erratic figures (Mukaila *et al.*, 2022).

The majority of arable farm land has insufficient soil fertility due to continuous cropping caused by land availability, which is one of the limiting factors affecting tomato yield (Echebiri *et al.*, 2025). The answer to this problem is the application of inorganic fertilizers. Inorganic fertilizers are also used by farmers to grow crops and vegetables (Roleda *et al.*, 2025). Several research have documented how applying these fertilizers increases the yield of several crops (Roleda *et al.*, 2025). One of the inorganic fertilizers that vegetable farmers commonly use is NPK (Musana *et al.*, 2025). Diminishing soil fertility is a crucial issue in a lot of African small holder farms, which has been worsen by constant agriculture without relevant soil fertilizer enhancement measures (Raheem *et al.*, 2025). However, the fact that chemical fertilizers can promote agricultural yields, their use is restricted as a result of their high cost, scarcity, nutritional imbalance, and acidic soil (Hayat *et al.*, 2026).

MATERIALS AND METHODS

Description of the experimental site: The experiment was conducted at an open space behind the Biological Sciences laboratory, Bosso Campus, Federal University of Technology Minna, the area lies on latitude 3° 20" East and longitude 11° 3" North.

Experimental Design: The experimental field was arranged in a randomized complete block design (RCBD) comprising five treatments: NPK (15:15:15) per 2kg and a control, each replicated ten (10) times.

Nursery Operation: The seeds were broadcasted in three plastic flower pots to germinate and grow for a period of two weeks (14 days). The plastic flower pots were filled with loamy clay soil obtained from the school farm.

Transplanting: Transplanting was done to nursery polythene bags containing loamy clay soil after one month. A set of ten polythene bags (26.8cm x 19.8cm) were assigned for each concentration of NPK fertilizer, and the control. They were left to stabilize for ten days before NPK fertilizer application.

NPK Fertilizer Application: NPK fertilizer was applied in a ring form 5cm from the seedling ten days after sowing with the exception of the control. Varying concentrations of 3.00g, 5.00g, 7.00g, 8.00g and 10.00g per 2kg of soil was applied to the tomatoes to ascertain the optimum NPK fertilizer for growth and development.

Statistically Analysis: Data collected were subjected to analysis of variance (ANOVA) using Duncan multiple range test (DMRT).

RESULTS AND DISCUSSION

Number of leaflets on the seedlings of *Lycopersicon esculentum* Mill treated to varying concentrations NPK Fertilizer:

The effect of NPK fertilizer concentration on the number of leaflets of *Lycopersicon esculentum* Mill seedlings is present in Figure 1 below. Prior to NPK fertilizer application, there was no significant difference ($p > 0.05$) in all the treatment, showing a uniform in the experimental seedlings. Whereas, after NPK application, there was an increase in the number of leaflets across all treatments. Across day five of NPK applications, seedlings showed higher leaflet numbers in contrast to the control but it was not statistically different in some cases. There was a significant difference ($p > 0.05$) in day ten and fifteen, where 5.00g treatment recorded the highest leaflets number followed by 7.00g and 3.00g treatment respectively. Day twenty after NPK application, 7.00g had the highest leaflets number, whereas the control recorded the lowest leaflets number all through the period of the study.

Number of leaflets on the seedlings of *Lycopersicon esculentum* Mill with lesions treated varying concentrations NPK Fertilizer:

The effect of NPK fertilizer concentration on the number of leaflets with lesions of *Lycopersicon esculentum* Mill seedlings were presented in Figure 2. Five days after the application of NPK fertilizer on the seedlings, there was no significant difference ($p > 0.05$) across the treatments. At day ten, the number of leaflets with lesions increased exponentially in all the treatments, especially seedlings with high treatments. Seedlings with 10.00g treatment showed the highest number of lesions, followed by 5.00g and 8.00g treatment respectively. At day twenty, all the seedlings treated with varying concentration of NPK fertilizer showed significantly higher lesions on their leaflets compared to the control.

Number of dead leaflets on the seedlings of *Lycopersicon esculentum* Mill treated to varying concentrations NPK Fertilizer:

The effect of NPK fertilizer concentration on the number of dead leaflets of *Lycopersicon esculentum* Mill seedlings were presented in Figure 3 below. There is no significant difference among treatments ten days after NPK fertilizer application. With higher NPK fertilizer concentrations at fifteen and twenty days, there was an increase in leaf mortality. 5.00g and 8.00g showed a considerable higher number of dead leaflets in day twenty of NPK fertilizer application, while that of the control treatment had the lowest values.

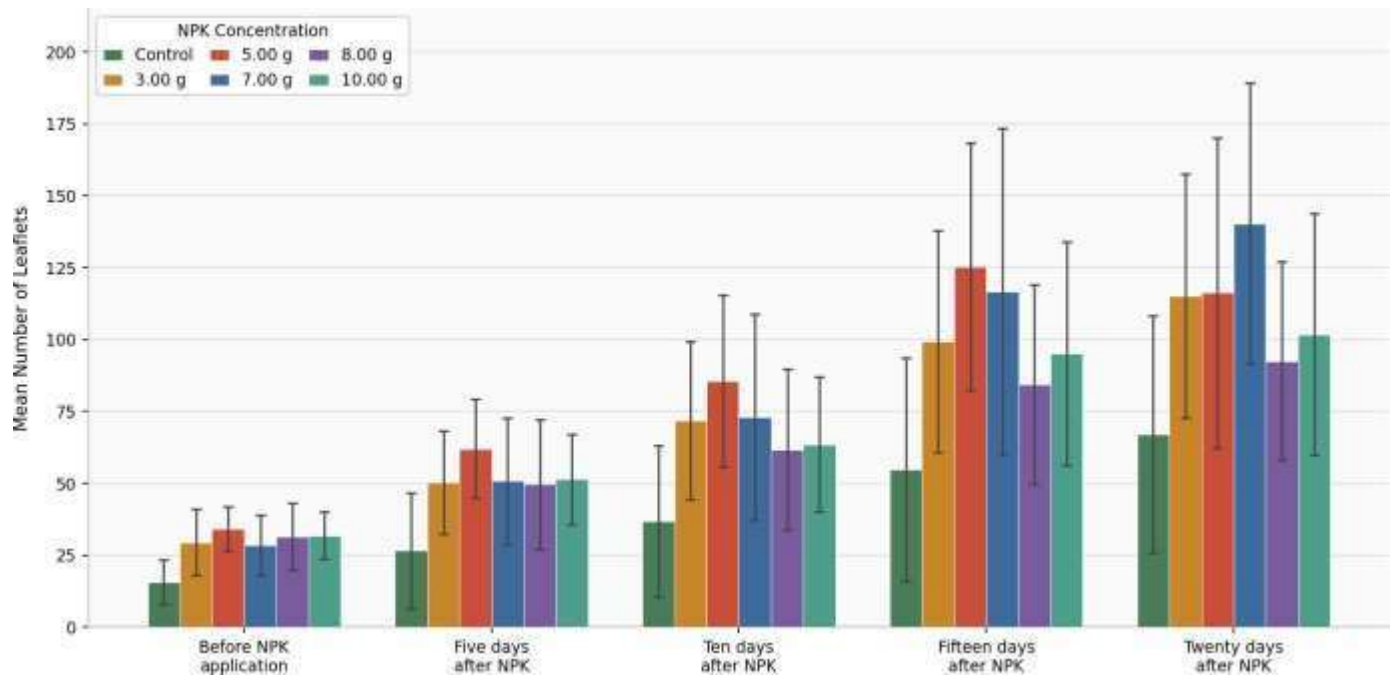


Figure 1: Mean Leaflet Counts of *Lycopersicon esculentum* Mill by NPK Concentration and Sampling Interval. (Error bars represent $\pm$ SD. Each colour represents one NPK treatment concentration.)

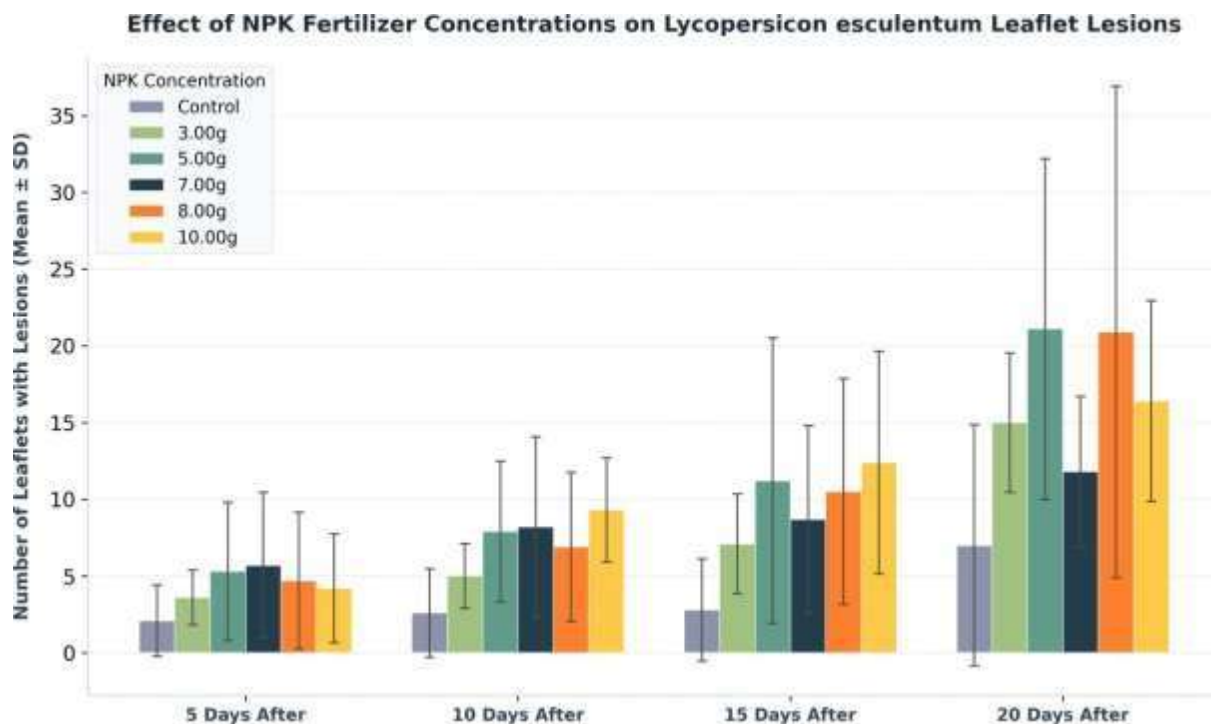


Figure 2: Mean number of leaflets with lesions across varying sampling intervals and NPK fertilizer applications. (Error bars represent Standard Deviation ($\pm$ SD))

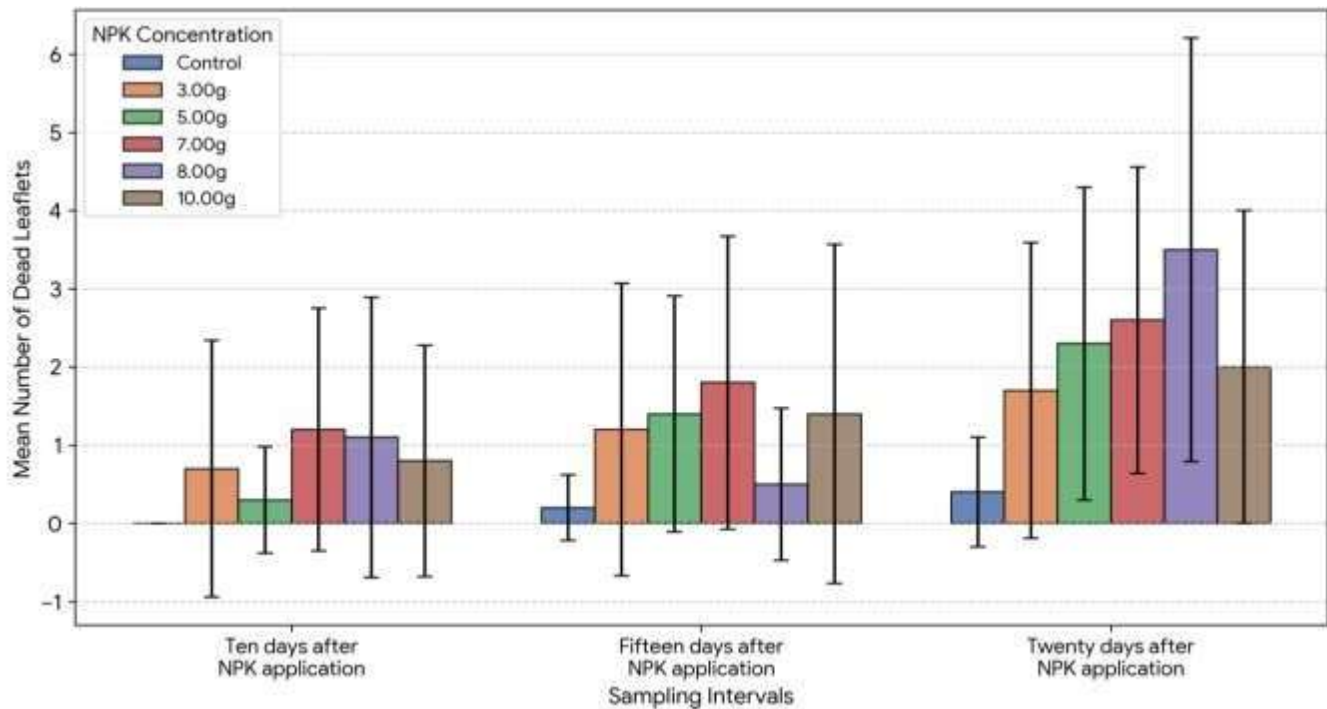


Figure 3: Clustered bar chart showing mean numbers of dead leaflets with standard deviation error bars.

The present study evaluated the response of *Lycopersicon esculentum* Mill (tomato) seedlings to varying concentrations of NPK fertilizer, focusing on leaflet production, lesion development, and leaflet mortality. The findings reveal a clear relationship between fertilizer application rate in relation to growth performance and physiological stress in tomato seedlings.

The results showed the effect of varying concentrations of NPK fertilizer on the seedlings of *lycopersicon esculentum* Mill (tomato) on the number of leaflets, lesion development on the leaflets, and leaflets mortality. The result revealed a relationship between NPK fertilizer application with growth development and physiological stress in tomato seedlings. Increase in the number of leaflets in all the treatment ascertains the importance nitrogen, phosphorus, and potassium with regards to plant growth. The 5.00g and 7.00g treatments showed that reasonable amount of fertilizer concentrations leads ideal nutrient accessibility, boosting vegetative growth. The decrease in the growth development as a result of high NPK fertilizer concentrations (8.00g and 10.00g) revealed nutrient imbalance. High fertilizer application interrupt nutrient absorption which causes osmotic tension, leading to restriction of plant growth. This is in agreement with the findings of Adaramoye *et al.* (2022), where the highest number of leaves were obtained from plants that received

60 kg N/ha and the least number of leaves was recorded for 90 kg N/ha. Also, this study is similar to the findings of Daocheng *et al.* (2023); who observed that N, P, and K play critical roles in plant growth and development. Under conditions of excesses or deficiencies of these major nutrients, plants respond by adjusting their morphology, physiology, photosynthetic ability, and metabolism.

The higher NPK fertilizer concentrations result in increase in leaflet lesions as a result of too much nutrient uptake, which negatively affect plant health. Soft plant tissues as a result of high nitrogen levels are prone to environmental stress and disease invasion. This aligns with the study of Daocheng *et al.* (2023), who observed that excesses or deficiencies of major nutrients makes plants adjust their physiological processes. Likewise, high number of dead leaflets with respect to higher NPK fertilizer concentrations imply that extended risk to undue nutrient uptake causes cellular damage, senescence, and tissue death. This agrees with the study of Daocheng *et al.* (2023), who observed that under conditions of excesses or deficiencies of these major nutrients, plants respond by adjusting their morphology, physiology, photosynthetic ability, and metabolism. Generally, the results showed a poise with regards to growth and plant health. Likewise, modest NPK fertilizer application improves vegetative

growth, too much NPK application cause detrimental effects, comprising elevated lesions and leaf mortality.

CONCLUSION

This research evidently proves that the application of NPK fertilizer has a substantial impact on both the growth performance and physiological state of tomato (*Lycopersicon esculentum* Mill) seedlings. The results reveal that reasonable amount of NPK fertilizer, especially at 5.00g and 7.00g concentrations support ideal vegetative growth as demonstrated by the elevated number of leaflets. This finding also substantiates the crucial part of nitrogen, phosphorus, and potassium in promoting plant development and enhancing general productivity.

Nevertheless, this research also divulges that extreme application of NPK fertilizer (particularly at 8.00g and 10.00g) leads to detrimental impact on plant vigour. This comprise of growing prevalence of leaflets lesions and elevated rates of leaf death. Such unfavourable result propose that undue nutrient supply can interrupt physiological stability, cause stress conditions, and eventually diminish plant vigour. The findings hence emphasize the fragile stability between nutrient adequacy and harmfulness in crop production.

Basically, whilst NPK fertilizer is essential for improving tomato growth, its application need to be cautiously controlled. Both deficient and extreme use NPK fertilizer can restrict plant performance, ensuring appropriate amount a vital determinant in attaining sound growth and viable.

RECOMMENDATIONS

NPK fertilizer should be applied at a reasonable rate to get ideal growth and to avoid physiological stress. Steer clear of excessive use of NPK fertilizer to avoid nutrient imbalance, heightened vulnerability to infection, and damage to leaf which eventually leads to diminished harvest quality. After NPK fertilizer application, farmer should closely monitor their crops for early detection of signs of stress such as leaf lesions or wilting, to enabling prompt adjustments. Also, carrying out soil analysis before applying NPK fertilizer is of vital importance to ascertain the exact nutrient levels and to avoid excessive use of fertilizer. Furthermore, follow-up studies should be done under natural conditions and across diverse soil types and ecological zones to substantiate these findings and expand

a region-specific guideline for applying the right type and amount of nutrients to crops.

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EXPLORING SOCIO-ECONOMIC AND CONTEXTUAL FACTORS CONTRIBUTING TO SCIENCE ANXIETY

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ABSTRACT

Science anxiety is a critical impediment to effective learning and engagement in science education, particularly within the domains of science, technology, engineering, and mathematics (STEM). This phenomenon encompasses heightened fear, negative emotional arousal, and avoidance behaviors associated with science-related tasks and environments. This study investigates the socio-economic and contextual determinants that exacerbate science anxiety among secondary school students in Nigeria. Utilizing a cross-sectional research design, data were collected from a sample of 500 students through validated survey instruments, including the Abbreviated Science Anxiety Scale, to measure anxiety levels alongside demographic variables such as age, gender, socio-economic status, urban or rural context, and educational level. The control-value theory of achievement emotions provided the theoretical lens, indicating how perceptions of control and value in academic settings influence emotional responses. Descriptive analyses revealed a mean science anxiety score of 74.02, with significant variations across groups: lower socio-economic status, rural residency, female gender, and junior secondary education were associated with elevated anxiety. Inferential statistics, including ANOVA, t-tests, and multiple regression, confirmed these factors as robust predictors, with low socio-economic status emerging as the strongest contributor. Implications underscore the need for equitable educational policies, while recommendations advocate for targeted interventions like resource enhancement in underserved areas and anxiety mitigation training for educators.

Keywords: Science Anxiety, Socio-Economic Status, Contextual Factors, Control-Value Theory, Stem Education.

INTRODUCTION

Science anxiety, a specialized form of academic anxiety, has been a subject of scholarly interest for decades, reflecting its profound impact on students' educational trajectories and broader societal advancements in scientific literacy. Initially conceptualized in the late 20th century, science anxiety refers to the emotional distress, fear, and physiological arousal experienced by individuals when engaging with science content, experiments, or assessments (Mallow, 1981). This distress often leads to cognitive interference, such as difficulty concentrating or recalling information, ultimately hindering performance and persistence in science-related pursuits (Udo *et al.*, 2001). Early investigations, such as those by Okebukola and Jegede (1989) emphasized how science anxiety manifests in classroom settings, where students perceive science as intimidating due to its abstract nature and perceived irrelevance to daily life. Over time, this concept has evolved to encompass not only individual psychological predispositions but also external influences, including socio-economic disparities and environmental contexts that shape educational experiences.

The background of science anxiety research reveals a historical progression from viewing it as a personal deficit to recognizing it as a multifaceted issue intertwined with systemic inequalities. In the 1980s and 1990s, studies predominantly focused on college-level populations in Western contexts, identifying factors like inadequate prior preparation and negative teacher interactions as key contributors (Mallow, 1994). For instance, Udo *et al.*, (2004) documented how physics anxiety, a subset of science anxiety, correlated with avoidance of advanced coursework among undergraduates. These works laid the groundwork for understanding anxiety as a barrier to STEM participation, particularly for underrepresented groups. More contemporary literature has broadened this scope to include younger learner and diverse global settings. Recent studies, such as those by Megreya, Szucs and Moustafa (2021), have linked science anxiety to math anxiety, showing moderate associations with reduced academic achievement and career aspirations in STEM fields. Furthermore, the COVID-19 pandemic has amplified these concerns, with research indicating heightened anxiety due to disrupted learning environments and increased reliance on digital platforms, which often

exacerbate disparities for students in resource-poor settings (Lin *et al.*, 2019 and Shala *et al.*, 2021).

The statement of the problem centers on the persistent and widening gaps in science education outcomes, where socio-economic and contextual factors play pivotal roles in perpetuating science anxiety. In many developing nations, including Nigeria, students from low-income backgrounds face chronic stressors such as financial instability and limited access to educational resources, which heighten vulnerability to anxiety disorders (Lund *et al.*, 2018). Contextual elements, like living in rural areas with inadequate infrastructure or urban overcrowding, further compound these issues by limiting exposure to hands-on science activities (Yang *et al.*, 2023). Despite evidence from meta-analyses showing that poorer neighborhood conditions increase the odds of mental health challenges, including anxiety (Richardson *et al.*, 2015), there remains a paucity of research specifically examining science anxiety through a socio-economic lens in non-Western contexts. This gap is particularly acute given the global emphasis on STEM equity; unaddressed science anxiety not only impairs individual achievement but also contributes to broader societal losses in innovation and workforce diversity.

Relevant current literature underscores the additive effects of Socio-economic and contextual variables on anxiety. For example, a large-scale study by King *et al.*, (2022) found that adolescents in disadvantaged neighborhoods exhibited high levels of depression and anxiety, with implications for academic engagement. Similarly, Brenes *et al.*, (2008) reported that adults with lower education and disability status were more prone to anxiety, patterns that likely originate in school years. Some literature complements this by highlighting gender differences; Misra and McKean (2000) observed that females report higher science anxiety than males, potentially due to societal stereotypes and lower self-efficacy in STEM domains. Recent investigations, such as those by England *et al.*, (2019), confirm these disparities persist, with first-generation and minority students experiencing compounded effects. In educational settings, active learning approaches have been shown to both alleviate and, in some cases, intensify anxiety depending on implementation (Cooper *et al.*, 2018). A systematic review by Barroso *et al.*, (2021) synthesized data from 372 studies, revealing small-to-moderate negative correlations

between math/science anxiety and performance, moderated by demographic factors.

Integrating these insights, the study addresses the problem by conducting a primary investigation into socio-economic and contextual contributors to science anxiety among Nigerian secondary students. Nigeria provides a compelling case study, with its diverse socioeconomic landscape and educational challenges where science literacy is crucial for national development yet hampered by inequities. By merging historical and contemporary perspectives, this research aims to elucidate how factors like family income, parental education, and geographic location interact to exacerbate anxiety, informing targeted interventions. The literature gap in primary data from African contexts necessitates this approach, as most existing studies rely on Western samples or secondary analyses. For instance, while Okebukola *et al.*, (1989) linked education levels to anxiety regulation, applications to science-specific anxiety in resource -constrained environments are limited. This study thus contributes by employing empirical methods to test these relationships, building on foundational works like Mallow (2006), who advocated for anxiety reduction clinics in science teaching, and newer frameworks emphasizing contextual moderation (Pekrun & Loderer, 2020).

The evolution of science anxiety research also highlights methodological advancements. Early studies often used qualitative observations or basic surveys (Okebukola 1986), while recent ones incorporate psychometric tools and longitudinal designs (Dakar *et al.*, 2021). However, few integrate socio economic metrics with anxiety measures in a holistic model. This oversight is problematic, as socio economic status influences not only access but also psychological resilience; lower SES correlates with chronic stress, impairing cognitive functions essential for science learning (Esch *et al.*, 2014). Contextual factors, such as neighborhood safety and school quality, add layers of complexity, as evidenced by Yang *et al.*, (2023), who associated environmental pollutants in disadvantaged areas with increased anxiety risk. In Nigeria, where urban-rural divides are stark, rural students often contend with outdated curricula and teacher shortages, fostering a sense of helplessness that aligns with anxiety theories (King *et al.*, 2022).

Moreover, the intersectionality of these factors with demographics like gender and age warrants attention. Older literature, such as Maloney (2015), noted intergenerational transmission of anxiety, where parental attitudes influence children. Newer studies extend this to cultural contexts, showing that with patriarchal societies, females may internalize STEM as male dominated, heightening anxiety (Carey *et al.*, 2016). Age-related Patterns suggest that anxiety peaks in early adolescence due to developmental transitions (England *et al.*, 2019). These elements form the crux of the problem: without addressing socio-economic and contextual roots, efforts to mitigate science anxiety remain superficial.

This article's structure reflects a standard journal format, beginning with this integrated introduction, followed by methodology, results, discussion, and conclusion. By citing both seminal works e.g., (Mallow, 1981) and recent analyses (e.g., Megreya *et al.*, 2021), it bridges temporal gaps in the literature, emphasizing the enduring relevance of science anxiety amid evolving educational landscapes.

Theoretical Framework: The theoretical foundation for this study is anchored on the control-value theory of achievement emotions, proposed by Pekrun (2006), which posits that academic emotions like anxiety stem from subjective appraisals of control over outcomes and the intrinsic or extrinsic value assigned to those outcomes. In the context of science education, students appraise their ability to master concepts (control) and the relevance of science to their goals (value). Low perceived control, often stemming from socio-economic constraints like limited access to tutors or materials can trigger anxiety, especially when high value is placed on success for future opportunities (Pekrun *et al.*, 2007). This theory integrates cognitive and emotional processes, explaining why students from disadvantaged backgrounds experience heightened distress in science classes, where failure perceptions are amplified by resource scarcity.

Complementing this is Bandura's (1997) social cognitive theory, which emphasizes self-efficacy as a mediator between environmental factors and emotional responses. Self-efficacy, the belief in one's capability to execute tasks, is eroded in low-SES contexts due to vicarious experiences of failure or lack of mastery opportunities, fostering anxiety (Gaudier-Diaz *et al.*, 2019). For rural students, contextual isolation reduces modeling from successful

peers, further diminishing efficacy. The theory also accounts for reciprocal determinism, where anxiety influences behavior (e.g., avoidance) and environment (e.g., poor grades reinforcing low SES cycles).

These frameworks are supported by older anxiety models, such as Spielberger's (1972) state-trait anxiety distinction, where trait anxiety (stable predisposition) interacts with state anxiety (situational) in educational settings. Recent applications, like in Hartanto and Yanga (2022), link this to cognitive load in science tasks. In Nigeria, where educational inequities are pronounced, these theories illuminate how socio-economic factors reduce control appraisals, while contextual variables like school infrastructure affect value perceptions.

The integration of these theories provides a robust lens for examining science anxiety. Control value theory guides the hypothesis that low SES and rural contexts lower control, increasing anxiety, while social cognitive theory explains efficacy's role. This dual approach addresses literature gaps, where older studies focused on individual traits (Mallow 1981) and newer ones on contextual moderation (Disentangling the individual and contextual effects of math anxiety, 2022).

METHODOLOGY

This study adopted a quantitative, cross-sectional research design to explore the relationships between socio-economic, contextual factors, and science anxiety. Cross-sectional designs are appropriate for capturing prevalence and associations at a specific time, allowing for efficient data collection from diverse groups. The design facilitated the examination of demographic variations without longitudinal demands, aligning with resource constraints in the study setting.

Participants were 500 secondary school students from public schools in Ogun State, Nigeria, selected via stratified random sampling to ensure representation across socio-economic strata, urban/rural divides, and education levels. Inclusion criteria included ages 12-18 and enrollment in science courses. The sample's demography reflected national trends: mean age 14.97 years (SD=2.04), with balanced gender distribution (45.4% male, 54.6% female). Socio-economic status was categorized based on parental occupation, income, and education: 43.4% low, 35.2% medium, 21.4% high. Contextual distribution was

55.8% urban, 44.2% rural, and education levels split between junior (54.6%) and senior secondary (45.4%).

Primary data collection employed a self-administered questionnaire, the preferred method for sensitive topics like anxiety to ensure anonymity and reduce bias. The instrument comprised two sections: demographics (age, gender, SES proxy questions, context, education level) and the Abbreviated Science Anxiety Scale (ASAS; Megreya *et al.*, 2021), a JO-item Likert-scale measure (1=strongly disagree to 5=strongly agree) assessing learning and evaluation anxiety (e.g., "I won't worry about failing science tests"). The ASAS has demonstrated reliability ($\alpha=0.82-0.89$) and validity in similar populations. Scores were summed (range 1-50), then scaled to 0-100 for interpretability. Pilot testing with 50 students confirmed clarity and cultural appropriateness, with minor wording adjustments.

Data collection occurred in classrooms during school hours, following ethical approval from the local education board and informed consent from participants and guardians. Teachers facilitated distribution, ensuring

voluntary participation. Response rate was 92%, with incomplete forms excluded.

Data analysis used descriptive statistics for demographics and anxiety levels, inferential tests (tests for binary variables like gender/context, ANOVA for SES, Pearson correlation for age), and multiple linear regression to predict anxiety from predictors. Analyses were conducted in Python with libraries like pandas and scikit-learn, with significance at $p<0.05$. Assumptions (normality, homoscedasticity) were verified via Shapiro-Wilk and Levene's tests.

RESULTS

The demographic profile of the 500 participants is summarized in Table I, illustrating a diverse sample representative of Nigerian secondary students. The mean age was 14.97 years ($SD=2.04$), ranging from 12 to 18. Gender distribution showed a slight female majority (54.6%), consistent with enrollment patterns in the region. Socio-economic status revealed 43.4% in the low category, reflecting prevalent economic challenges. Contextual factors indicated 55.8% urban residents, while education levels were nearly evenly split between junior and senior

Table 1: Demographic Characteristics of Participants

Variable	Count/Mean	Percentage
Gender: Female	273	54.60%
SES:Low	217	43.40%
SES: Medium	176	35.20%
SES: High	107	21.40%
Context: Urban	279	55.80%
Context: Rural	221	44.20%
Education Level: Junior Secondary	273	54.60%
Education Level: Senior Secondary	227	45.40%

Table 2. Science Anxiety Scores by Socio-Economic Status

SES	Mean	SD	Count
Low	82.39	12.03	217
Medium	71.43	12.26	176
High	61.32	12.66	107

Table 3. Science Anxiety Scores by Context

Context	Mean	SD	Count
Rural	80.83	13.47	221
Urban	68.63	13.40	279

Table 4. Science Anxiety Score by Gender

Context	Mean	SD	Count
Female	76.24	14.52	273
Male	71.35	14.55	227

Table 5. Science Anxiety Scores by Education Level

Education level	Mean	SD	Count
Junior Secondary	75.43	14.29	273
Senior Secondary	72.32	15.09	227

The overall mean science anxiety score was 74.02 ($SD=14.72$), indicating moderate to high levels across the

sample. Group comparisons revealed significant differences, By SES (Table 2), low SES students had the highest mean (82.39, SD = 12.03), followed by medium (71.43, SD = 12.26) and high (61.32, SD = 12.66). ANOVA confirmed these differences ($F = 112.09$, $p < 0.001$).

Contextual differences, Table 3 showed rural students with higher anxiety, 80.83 (SD = 13.47) than urban (68.63, SD = 13.40), $t = -10.09$, $p < 0.001$.

Gender analysis, Table 4 indicated females had higher scores (76.24, SD = 14.52) than males (71.35, SD = 14.55), $t = -3.75$, $p < 0.001$.

Education level (Table 5) showed junior students more anxious (75.43, SD = 14.29) than seniors (72.32, SD = 15.09), $t = 2.36$, $p = 0.019$.

Age correlated weakly and non-significantly with anxiety ($r = -0.06$). Multiple regression (Table 6) explained 55% variance (adjusted R^2 approximate from model fit). Low SES ($\beta = 21.41$) and rural context (negative urban $\beta = -12.63$) were strongest predictors, followed by female gender (negative male $\beta = -4.64$) and junior level (negative senior $\beta = -4.24$).

Age had minor negative effect ($\beta = -0.76$).

These results demonstrate clear patterns, with socio-economic and contextual factors exerting substantial influence.

DISCUSSION

The findings illuminate the significant role of socio-economic and contextual factors in science anxiety, aligning with and extending existing literature. The elevated anxiety in low SES students mirrors Richardson *et al.*, (2015), where neighborhood has disadvantages incremental depression odds, applicable to science-specific distress. This may stem from chronic stressors like financial instability, reducing cognitive resources for science engagement (Esch *et al.*, 2014). Rural contexts' higher scores support Yang *et al.*, (2023), attributing anxiety to environmental and infrastructural deficits.

Gender differences, with females more anxious, echo Misra and McKean (2000) and recent works (England *et al.*, 2019), possibly due to stereotype threat. Junior students' higher anxiety suggests developmental vulnerability, consistent with Pekrun (2006). The weak age correlation indicates other factors dominate.

Regression results affirm the theoretic framework: low control from SES/context predicts anxiety. Compared to older studies (Okebukola, 1986), this highlights persistent issues, while new insights (Megreya *et al.*, 2021) suggest interventions targeting efficacy. Limitations include self-report biases and generalizability beyond Nigeria. Future research should use longitudinal designs.

CONCLUSION AND RECOMMENDATIONS

This study conclusively demonstrates that socio-economic disadvantages and rural contexts significantly contribute to science anxiety, impacting educational equity. By integrating primary data with theoretical insights, it advances understanding of these dynamics in Nigeria.

Recommendations include policy reform for resource equalization, teacher training in anxiety reduction (e.g., active learning per Cooper *et al.*, 2018), and community programs to boost self-efficacy. Also, schools should implement screening and support for high-risk groups.

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DEVELOPMENT OF A WEB SITE FOR ADVANCED PUBLIC TRANSPORTATION SYSTEM IN MINNA METROPOLIS, NIGER STATE NIGERIA

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ABSTRACT

Traffic congestion and ineffective public transportation management remain major challenges in urban centres in Nigeria, particularly in Minna metropolis, Niger State. This study developed a web-based Advanced Public Transportation System (APTS) aimed at improving transportation management and reducing commuter waiting time through the application of Intelligent Transportation Systems (ITS). The study adopted a survey research methodology involving vehicle departure time surveys conducted across selected transport routes in Minna for seven consecutive days. Data collected were analyzed to determine vehicle movement patterns, commuter demand, and scheduling requirements. The system was developed using HTML5, CSS3, PHP, and MySQL database technologies. Findings revealed that the developed system can effectively automate trip scheduling, provide real-time travel information, reduce commuter waiting time, and improve transport service management. The study concluded that the implementation of web-based APTS can significantly enhance urban transportation efficiency in Minna metropolis.

Keywords: Intelligent Transportation System (ITS), Web site, Metropolis, Development, Commuter

INTRODUCTION

Transportation has become one of the basic necessities of human society. In recent years providing effective means of transportation has become a challenge for cities around the world. These challenges include congestion, safety, lack of proper and adequate transport infrastructure, under funding and the environmental impacts of growing traffic. It is estimated that severe congestion has an economic impact of one to three percent of GDP in developed and developing countries (Houghton et al., 2010). The first national land transport policy in Nigeria was driven in twentieth centuries, aimed to modernize transport sector (Premium Times, 2025), while Etcetera Consults Ltd, (2025) stated that smart traffic management and electric vehicles are needed for modern transportation systems in Nigeria. One of the effective ways of tackling these challenges is the use of advanced technologies in transportation systems management. The nature of the challenges and the solutions depend on the characteristics of physical developments, existing infrastructure and the behaviour of commuters.

Adeola et al., (2024) ‘Leveraging Technology for Enhanced Road Transportation in Nigeria’ stated that road transportation in Nigeria can be improved by intelligent transportation systems and electric vehicles. The use of advanced technologies comes under the broad category of Intelligent Transportation Systems (ITS) which encompasses a range of advanced technologies that are applied to surface transportation needs including transit and highway needs. Information and

Communication Technology (ICT) by Amadi et al., (2018) can be used in Nigeria transportation systems, and this ICT, including intelligent transportation systems improved safety, reduced congestion, and environmental benefits. The concept of ITS was introduced in the 1960s when urban areas attempted to deal with increasing traffic congestion (Singh & Kumar, 2011).

Public transportation in Minna metropolis faces significant inefficiencies that negatively impact the socio-economic activities of commuters daily, such as, lack of route information, inefficient ticketing and poor fleet management. This study specifically aimed to design and develop a web-based Advanced Public Transportation System (APTS) for Minna metropolis to digitize transit operations by mapping out major public transport route terminals and stops across Minna Metropolis using interactive Geographic Information System (GPS) and by creating a functional journey-planning module that allows commuters to view available routes and estimated travel times (Owoeye et al., 2022).

METHODOLOGY

Description of Minna: Minna is the capital of Niger State, Nigeria. The study area (Figure 1) lies between Latitude 9° 33' and 9° 40' North, and Longitude 6° 29' and 6° 35' East on a geological base of undifferentiated basement complex of mainly gneiss and magnetite. At the North –east corridor of the town lies a continuous steep outcrop of granite, which forms a limitation towards physical development in that axis. In the present

political zoning system in Nigeria, it is within the North Central Zone and occupies an area of about 884 hectares. It is about 145 kilometres by road from Abuja, the Federal Capital of Nigeria. Minna town has grown to engulf suburbs settlements such as Chanchaga, Bosso,

Maitunbi, Dutsen Kura, Kpakungu and Shango. The town is presently growing linearly along the main spine road from Chanchaga in the south to Maikunkele in the north, a distance of about 20 kilometres.

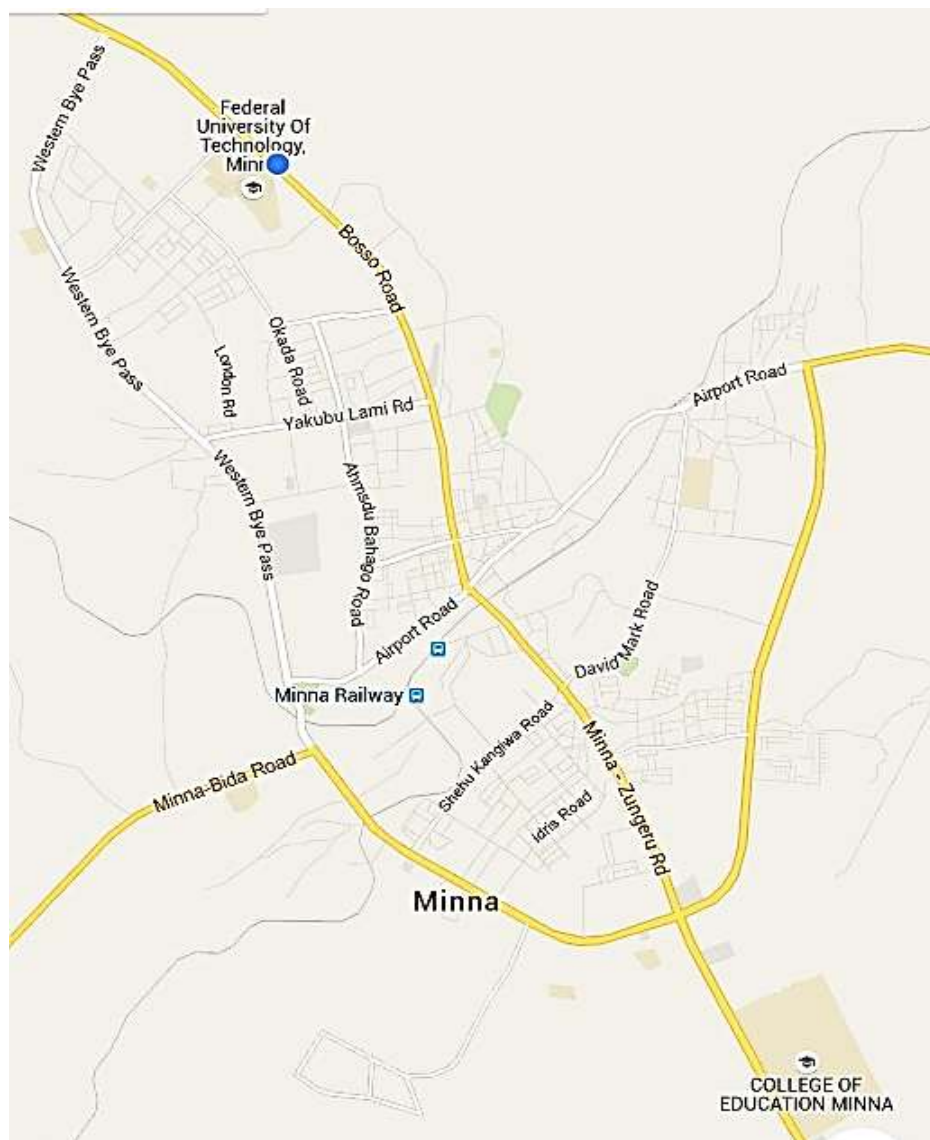


Figure 1: Map of Minna (Google Map, 2026)

Terminals and Travel Routes: Seven terminals were identified based on the original destination survey and successfully integrated into the developed software for route mapping and transport scheduling. The identified terminals served as the operational nodes of the system, while the travel routes established the connectivity between terminals.

The identified terminals are listed below:

1. Mobil roundabout bus/taxis terminals.
2. Chanchaga bus terminal
3. Bosso bus terminals.
4. Kpagugu bus terminal.

5. Maitumbi bus terminal.
6. Federal University of Technology Bosso, bus terminal.
7. Federal University of Technology permanent site, bus terminal.

The developed system successfully mapped the major travel routes between these terminals, enabling efficient route identification and transport coordination. The routes identified include:

1. Mobil roundabout- Chanchaga
2. Mobil roundabout- Bosso

3. Federal University of Technology Bosso Campus – Federal University of Technology permanent site (PS)
4. Mobil roundabout – Kpakungu
5. Mobil roundabout -Maitumbi

Vehicle Departure Time Survey: Vehicle departure time survey was carried out for 7 consecutive days on five routes used in the study. The purpose was to determine the movement patterns of the commercial buses along the selected routes and to quantify the number of buses and departure schedules that will meet the demands of the travelers (Slack,1992). Data on the departure times of the commuting buses from the terminals were collected for seven days on five routes, namely Route 1, which is the link from Mobil roundabout Terminal to Chanchaga Bus Terminal; Route 2, which is the link from Mobil roundabout to Bosso Bus Terminal; Route 3, which is the link from Federal University of Technology (FUT) Minna, Bosso Campus to FUT Minna Permanent Site (PS) Bus Terminals; Route 4, which is the link from Mobil roundabout to Kpakungu terminal, and Route 5 is the link from Mobil roundabout to Maitumbi terminal. The Survey focused on bus, taxis and tricycles

traffic. The 12-hour, 7-day survey commenced at 7:00 am and ended at 7:00pm.

Website Development: The website development was divided into phases;

- i. **User interface (UI) Development:** The user – interface was designed using Hypertext Markup Language (HTML5) and Cascading Style Sheet (CSS3) for a beautiful appearance, forms applications and to enable input of elements such as filling/collecting user’s data. HTML5 was used to design the registration forms, booking forms, etc. While CSS3 was used to handle the look and feel of the site (Kumar et al., 2024)
- ii. **Server-side scripting:** Server-side scripting was done using Personal Home Page (PHP) programming language. The PHP enables interaction / communication between the site/web pages and the database. The PHP code was scripted using Object Oriented Programming (OOP) approach to query data in the database, input, edit/ modify or delete data from the database.

My Structured Query Language (SQL) database was used to handle all data being processed from the web page.

RESULTS AND DISCUSSION

Table 1. Vehicular Departure Time along different routes and days in Minna Metropolis

Route	Day1	Day2	Day3	Day4	Day5	Day6	Day7
Departure Waiting Time (mins)							
1	87	91	85	85	93	93	81
2	48	46	45	47	50	49	46
3	87	91	85	81	76	91	77
4	139	111	119	117	115	129	116
5	85	79	87	82	82	76	83
6	144	153	156	149	147	147	149

Table 1 illustrates the variation in vehicle departure times across some selected routes during specific periods of the day. The presentation of the data was structured to distinguish between the different categories of vehicles and their operational patterns. From the analysis, an average departure waiting time of vehicles along Route 1 between days 1 - 7 are approximately between 81 – 93 minutes intervals. Also, the average departure waiting time for route 2 between days 1 and 7 fall within 45 to 50 minutes respectively. While for the average departure waiting time for days 1 to 7 are between 76 to 91 minutes. Repeating the processes for the remaining routes which are routes 4, 5 and 6 respectively for their average departure waiting time values indicate between 111 to 139 minutes; 76 to 87 minutes and 144 to 153

minutes intervals respectively. The analysis indicates that vehicle movement and passenger demand varied across the different periods of the day, with peak transport effective waiting times observed at route 6 during the period of the days. This demonstrates the need for adequate vehicle supply and effective scheduling to meet commuter demand along the identified routes as was also shown by Jimoh & Adeleke (2005). The developed system will enable easy management of transportation services through proper inventory of trips and commuters.

It should however be noted that the scope of this study is restricted to Minna metropolis and does not cover the entire Niger State or Nigeria as a whole. Therefore,

generalization of the findings beyond the study area should be done with caution.

CONCLUSION

Result from this research work indicate that the average minimum departure waiting time values at route 2 for the all days are between 45 to 50 minutes, while the average optimum departure waiting time at the route 6 was 144 to 153 minutes.

RECOMMENDATIONS

- i. Commercial vehicle operators, both private and public, should be educated on the advantages of adopting the Intelligent Transport System (ITS) subsystem of APTS to achieve the goals of APTS in Minna metropolis.
- ii. Commuters should be adequately informed about the developed website for its effective use and to enable them appraise its efficiency.
- iii. Seminars and workshops should be organized to encourage and provide incentives for the pilot implementation of projects using APTS technology in various localities and under different conditions so as to promote the adoption and sustainable use of such systems in Nigeria.

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ASSESSMENT OF SUPPLY CHAIN MANAGEMENT PRACTICES IN NIGERIAN CONSTRUCTION FIRMS

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ABSTRACT

This study investigates the adoption of supply chain management (SCM) practices in Nigerian construction firms, with a focus on Abuja. The research identifies key practices and challenges faced by construction stakeholders in the region. Data was collected using a self-administered questionnaire, which predominantly consisted of closed-ended questions, and responses were measured on a five-point Likert scale. The findings reveal that the most commonly adopted SCM practices in the sector are focused on enhancing efficiency, particularly through the reduction of waste (MIS = 4.18), time (MIS = 4.10), and costs, alongside the sharing of knowledge and skills (MIS = 4.06). However, challenges such as the inability to integrate internal processes (MIS = 4.42) and resistance to change (MIS = 4.38) remain significant barriers to effective SCM implementation. The study highlights that while practices like waste reduction and knowledge sharing are widely adopted, key areas such as supplier relationships (MIS = 3.62), transparency (MIS = 3.68), and the adoption of new technologies (MIS = 2.63) are underdeveloped. The research underscores the need for a more integrated approach to SCM, with a focus on fostering long-term partnerships and embracing technological advancements. Based on these findings, the study recommends improving collaboration, investing in technological solutions, implementing robust change management strategies, providing ongoing training, and strengthening supplier development to enhance SCM practices and overall efficiency in the Nigerian construction industry.

Keywords: Challenges, Construction Industry, Digital Technologies, Supply Chain Management (SCM), Stakeholder Collaboration

INTRODUCTION

Supply chain management (SCM) practices play a pivotal role in shaping construction project outcomes on a global scale. Current international perspectives highlight the importance of digital integration, enhanced visibility through the Internet of Things (IoT), and predictive analytics to develop resilient sourcing strategies that can withstand global logistics disruptions (CMiC Global, 2026). In South Africa, Oke *et al.* (2024) identify key success drivers, including reliable supplier databases, automated logistics, efficient feedback systems, and a deep understanding of stakeholders. However, in Nigeria, these practices remain fragmented, resulting in significant inefficiencies in material flow and project delivery (Adeyemo & Adebisi, 2025).

In Nigeria, poor infrastructure significantly hampers SCM practices. Inadequate road networks often cause delays in material transport and inflate logistics costs, leading to a fragmented supply chain and common project setbacks in the local industry. To mitigate these uncertainties, firms can adopt SCM strategies such as improved supplier coordination, robust inventory management, and real-time information sharing. The

implementation of digital platforms for tracking and collaborative planning is crucial in reducing transit volatility and enhancing overall reliability (Adeyemo & Adebisi, 2025).

Material shortages and price fluctuations further disrupt Nigerian construction firms, often resulting from heavy reliance on imports and local scarcity. These issues increase capital requirements and halt physical progress, exacerbating budget overruns and inaccurate cost estimations prevalent in the sector. Effective SCM strategies, such as strategic procurement, thorough vendor evaluation, and accurate demand forecasting, help mitigate these risks by ensuring a steady supply through diversified sourcing and the maintenance of buffer stocks (Ogunlana & Promkuntong, 1996).

Finally, inadequate stakeholder coordination undermines the effectiveness of SCM. Fragmented communication between contractors, suppliers, and regulators often leads to misaligned efforts, contributing to widespread delays. By prioritising relationship management, transparent feedback systems, and integrated logistics, firms can foster trust and joint decision-making, streamline

operations and improve performance across the construction industry (Oke *et al.*, 2024).

Supply chain management (SCM) practices within Nigerian construction firms have garnered significant scholarly attention, particularly regarding recurring patterns of inefficiency, adaptation strategies, and operational enablers. Dominant themes in the current discourse include SCM barriers, the impact of digital transformation, stakeholder collaboration, and the development of bespoke frameworks. These themes, largely derived from qualitative explorations and practitioner interviews, reveal a broad consensus on industry fragmentation alongside ongoing debates regarding adoption readiness.

Theoretical Framework: The Resource Dependence Theory (RDT) was developed in 1978 by Pfeffer and Salancik as an approach to analyze organizational dependence on external resources (Febrianti *et al.*, 2024). It suggests that organizations are not self-sustaining and have to interact with their environment in order to obtain essential resources like raw material, finances, and information, which are normally owned by other organizations (Jiang *et al.*, 2023). RDT highlights the importance of managing power and decreasing uncertainty within the organizational environment. According to the theory, it is resource control and dependence that define organizational behavior, interactions between organizations, and strategy development (Coşkun & Öztürk, 2024).

RDT is underpinned by the logic that organizational behavior occurs in response to limitations placed on an organization's resource availability due to environmental influences. In seeking greater independence from other organizations and greater resource dependency in order to ensure better stability and efficiency, firms engage in various behaviors (Kumari & Tiwari, 2025). The use of RDT as a tool for decision-making in strategy formulation, such as alliance and joint venture formation, M&A deals, and international supply chain management, has been identified in scholarly work. It allows firms to obtain vital resources and mitigate any weaknesses (Öztürk & Bağış, 2025; Arroyabe *et al.*, 2024). Studies prove that through resource management firms are able to increase efficiency and gain competencies.

Several authors have endorsed the use of RDT, noting that the theory offers a strong model through which organizational behavior as well as alternative strategies under conditions of dependence can be understood (Kohtamäki, 2024; Rashid *et al.*, 2024). These authors note that organizations are able to transform dependence into opportunity through the establishment of relationships that allow them access to resources, facilitate knowledge transfer, and provide increased opportunities for growth. Critics have noted that RDT is too much focused on environmental determinism and does not sufficiently take account of organizations' capacity to innovate and decrease dependence (Baraldi *et al.*, 2024). Some theorists have noted that there is some lack of specificity in addressing dependence and autonomy (Febrianti *et al.*, 2024).

Incorporating the RDT framework into the present research that focuses on the supply chain management practices of construction companies in Nigeria is instrumental in offering theoretical guidance for analyzing how firms deal with external dependencies from their suppliers, contractors, and others. As per the theory, it is valid to measure the degree of adoption of supply chain management practices in a bid to minimize uncertainty and gain more control over the resources required for undertaking projects (Jiang *et al.*, 2023; Coşkun & Öztürk, 2024). With an understanding of the dependency relations, the research will be able to determine how firms adopt certain practices to make their processes more efficient.

Empirical Review: Adeyemo and Adebisi (2025) examined the role of government policies in addressing supply chain challenges within the Nigerian construction industry, focusing on nationwide practices. Their study aimed to identify policy gaps contributing to disruptions such as material delays and cost overruns. They employed a quantitative survey methodology, distributing questionnaires to 150 construction professionals across various states and analysing the data through descriptive statistics and regression models. The findings revealed that weak regulatory frameworks and inconsistent import policies were responsible for over 60% of supply chain inefficiencies, with poor enforcement exacerbating reliance on foreign supplies (Adeyemo & Adebisi, 2025). The authors concluded that targeted interventions could improve resilience, recommending mandatory local

content policies and digital tracking systems to streamline material flows.

Building on this policy focus, Esan *et al.* (2025) investigated current supply chain management (SCM) practices in the Nigerian construction sector, drawing data from firms in Lagos and Abuja. The study aimed to assess the adoption of modern SCM techniques amidst economic volatility. Using a mixed-methods approach, they conducted semi-structured interviews with 50 supply chain managers and surveyed 200 respondents, employing thematic analysis and Spearman rank correlation for validation. The key findings indicated low integration of technology such as ERP systems, with only 25% of firms practising collaborative planning, which led to frequent delays (Esan *et al.*, 2025). They concluded that fragmented practices hinder competitiveness and recommended training programs to encourage the adoption of just-in-time inventory practices.

Moneke and Echeme (2016) provided an earlier benchmark by exploring SCM practices in the Nigerian construction industry, focusing on firms in South-Eastern states. Their main objective was to evaluate the extent of SCM implementation and its impact on project timelines. The methodology involved surveying 120 contractors using Likert-scale questionnaires, analysed through mean score ranking and chi-square tests to measure associations. The results revealed that poor information sharing among stakeholders was the leading barrier, contributing to 40% of cost variances, while partial SCM adoption improved project delivery by 15% (Moneke & Echeme, 2016). They concluded that integrated contracts were essential, recommending stakeholder workshops to foster trust and coordination.

Oke *et al.* (2024) shifted focus to the drivers of SCM implementation in construction project delivery, comparing cases from South African and Nigerian projects for cross-regional insights. The study aimed to identify motivators such as cost savings and risk reduction, using the Delphi method with 25 experts from both regions. Consensus was reached through three iterative rounds and content analysis. Findings revealed that client pressure and regulatory compliance were the main drivers, increasing efficiency by up to 30% in firms that adopted SCM practices. However, Nigerian cases lagged behind due to infrastructural deficits (Oke *et al.*,

2024). The conclusion emphasised SCM's potential for sustainability, with recommendations for government incentives to accelerate adoption in developing economies.

Okpo (2025) complemented these studies by exploring qualitative factors that enhance SCM implementation in the Nigerian construction industry, focusing on interviews from firms in the north and south. The aim was to identify enablers such as leadership commitment amidst contextual barriers. Using a phenomenological design, Okpo interviewed 20 senior managers and thematically coded the responses using NVivo software. The results identified strong supplier relationships and digital adoption as key enablers, mitigating 50% of delay risks, while policy instability remained a significant deterrent (Okpo, 2025). The study concluded that human-centric strategies are crucial, recommending capacity-building initiatives and public-private partnerships to institutionalise SCM practices nationwide.

RESEARCH METHODOLOGY

Research Design and Sampling Strategy: The study adopts a quantitative research approach using a survey questionnaire. This design allows for the systematic collection of numerical data from a representative sample of construction firms to evaluate the level of adoption of supply chain management practices (Creswell & Creswell, 2018). A structured questionnaire will be developed and distributed to managers, procurement officers, and project coordinators across selected firms, capturing information on procurement processes, supplier relationships, logistics management, and technology integration (Bryman, 2016). The data collected will be coded and analysed statistically to generate descriptive measures, such as frequencies, percentages, and mean scores, to quantify the adoption levels of supply chain practices. This approach ensures objectivity, consistency, and the ability to generalise findings to the broader population of construction firms in Nigeria (Field, 2018).

Choosing a quantitative survey design is justified because it allows for the collection of large-scale data within a limited timeframe, providing empirical evidence of current practices and adoption levels (Saunders, Lewis, & Thornhill, 2019). The design facilitates comparison across different types and sizes of construction firms, highlighting patterns and trends in supply chain

management implementation (Kothari, 2014). By focusing on measurable indicators, the study can identify gaps in practice and areas requiring improvement, offering practical insights for policy formulation, strategic planning, and operational decision-making. Additionally, this design supports the testing of hypotheses and the generation of actionable recommendations that are statistically grounded, enhancing the reliability and validity of the study outcomes (Creswell & Creswell, 2018).

Sample Composition: The study aims to identify the level of adoption and challenges of supply chain management practices among selected construction firms in Abuja, Nigeria. The population of the study consists of 140 employees drawn from relevant professional groups, including Quantity Surveyors, Architects, Builders, Civil Engineers, and other construction professionals. Since the population is known, Taro Yamane's formula was adopted to determine an appropriate sample size for the survey at a specified level of precision. Based on the calculation, the required sample size was approximately 105 respondents. After data collection and screening, 100 completed questionnaires were found usable for analysis. Therefore, the final usable sample size for the study was 100 respondents.

Instrumentation and Measurement Scale: The research instrument consisted of a self-administered questionnaire,

primarily featuring closed-ended questions. Responses were measured using a five-point Likert scale, with the following scale points: very high (5), high (4), slightly high (3), low (2), and none (1). Respondents' scores were calculated based on the variables included in the questionnaire.

Data Analysis Method: A descriptive statistical method was employed to summarise the sample data. Instead of using the data to make inferences about the broader population, descriptive analysis was used to present mean scores and frequency counts. Mean scores were utilised to rank respondents' opinions and responses obtained from the survey.

RESULTS AND DISCUSSION

The results of the demographic profile of the respondents that participated in this research work were presented in section 4.1 to 4.4 respectively.

Years of Experiences of Respondents in Construction Firms:

Figure 1 shows that 35.94% of the respondents have 11-15 years of work experience, while 26.56% have 6-10 years of experience. Additionally, 16.41% of the respondents have 1-5 years of experience, and 7.03% have 20 years or more of work experience. This indicates that the majority of the respondents possess significant experience in infrastructure projects, suggesting that the right individuals were selected for this research.

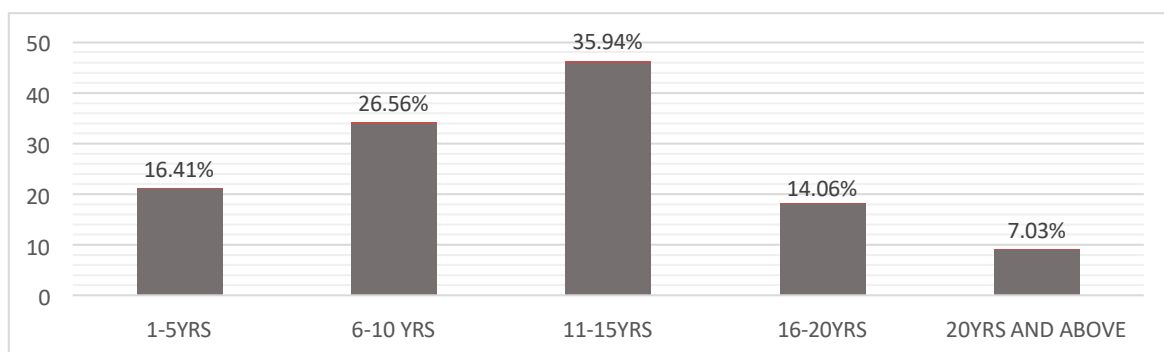


Figure 1: Years of Working Experiences in construction

Qualification of Respondents: Figure 2 shows the following qualifications of the respondents: 35.94% hold a B.Sc/B.Tech degree, 25% have an HND, 17.97% possess an MSc degree, and 6.25% have an ND. This reflects that

the respondents have the required qualifications across various backgrounds of knowledge relevant to infrastructure projects.

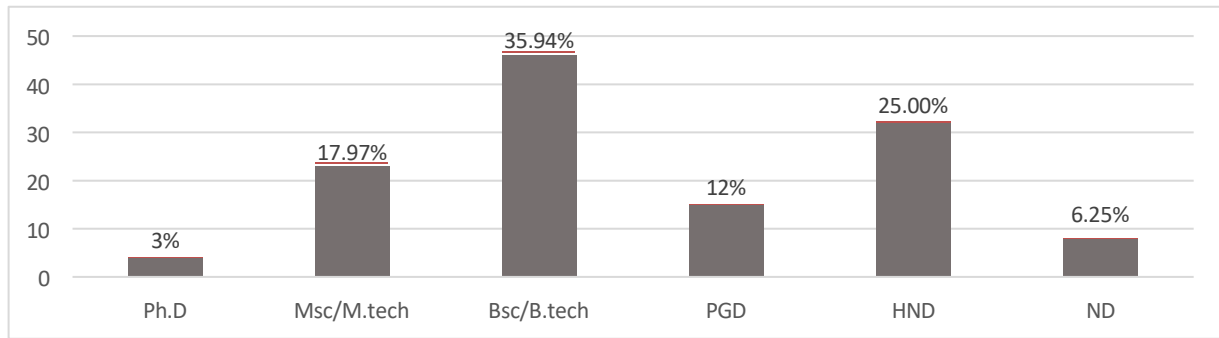


Figure 2: Qualification of Respondents

Activities of Respondents: Figure 3 shows that 42.19% of the respondents are consultants, while 35.94% are contractors. Additionally, 21.88% of the respondents are client representatives. This implies that the majority of the participants in this research are contractors, consultants, and clients, indicating that the respondents are individuals who are frequently involved in infrastructure projects.

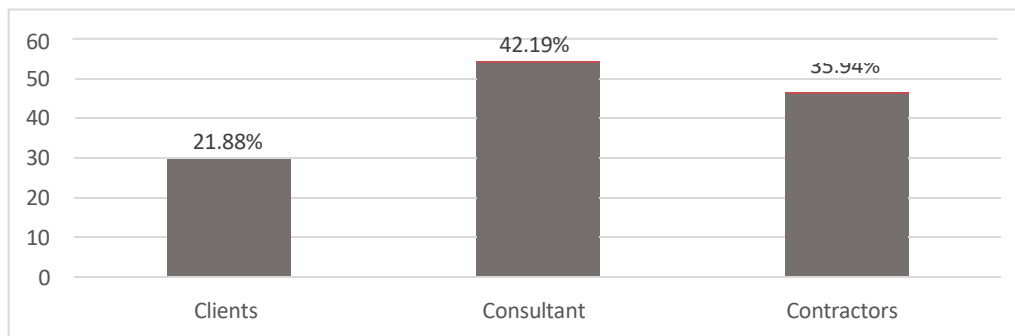


Figure 3: Activities of Respondents

Profession of Respondents: The profession of respondents that participated in this research works were analysed in Figure 4 and the result show that 37.5% of respondents are Quantity Surveyors, 28.91% are Architect; 16.41% are Engineers and 14.06% are Builders. This reflect that the professions of the respondents are the thus that required in the infrastructure projects.

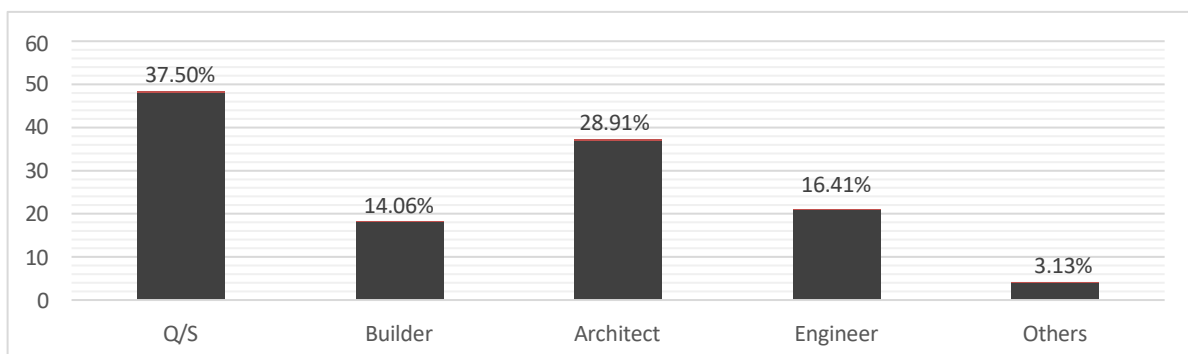


Figure 4: Profession of respondents

Adoption of SCM: The adoption of SCM were analysed to established the commonest level of adoption of SCM practices in the Nigerian construction firms as shown in Table 1

Table 1: Level of adoption

Components of SCM practices	MIS	Ranking
Reduction in wastage	4.18	1 st
Sharing and use of knowledge and skills	4.10	2 nd
Reduction in time	4.06	3 rd
Decrease in cost and expenses	3.95	4 th
Logistics management	3.90	5 th
Sharing information	3.68	6 th
Management of suppliers in the chain	3.62	7 th
Speed and flexibility in responding to clients demand	3.62	7 th
Early involvement of members	3.60	8 th
Adequate financial management	3.56	9 th
Long term integration and partnering	3.06	10 th
Strong financial flow	3.05	11 th
Incentive of suppliers	2.91	12 th
Strong relationship development and trust	2.84	13 th
Transparency between the suppliers	2.81	14 th
Dedication to same goal	2.76	15 th
Integrated project delivery	2.76	15 th
Development of suppliers in the chain	2.70	16 th
Building information management	2.63	17 th
Advancement of newest technology or products and techniques	2.44	18 th

Table 1 ranks SCM adoption levels in Nigerian construction firms, prioritizing operational gains like waste reduction (4.18) and knowledge sharing (4.10) over relational aspects such as trust-building (2.84) or supplier incentives (2.91).

Agreement exists with empirical reviews on the tangible benefits driving uptake. Esan *et al.* (2025) and Moneke and Echeme (2016) highlight high rankings for cost and time reductions, noting 15-30% efficiency gains from logistics and waste control in Lagos and southeastern firms, emphasising short-term outputs over integration (Esan *et al.*, 2025; Moneke & Echeme, 2016). Okpo (2025) also supports the idea of early member involvement (3.60), which is moderately adopted through supplier ties, aligning with mid-tier scores (Okpo, 2025). Disagreement arises concerning low relational practices. Adeyemo and Adebisi (2025) emphasize policy-driven

partnerships for trust and transparency, which are ranked 13th and 14th (2.81/2.84), yet find them fragmented nationwide. This contrasts with the results showing a lower emphasis on long-term integration (3.06), which Oke *et al.* (2024) identify as lagging in Nigeria compared to South Africa due to trust deficits (Adeyemo & Adebisi, 2025; Oke *et al.*, 2024).

Technology adoption is lagging (BIM 2.63, new techniques 2.44), which partially contradicts Esan *et al.* (2025), who note that ERP systems are underused at 25%, despite their potential. However, both studies agree on weaknesses in information sharing (ranked 6th), reinforcing the barrier rankings of Moneke and Echeme (2016) (Esan *et al.*, 2025; Moneke & Echeme, 2016). Overall, the findings align with reviews on operational priorities amid barriers but highlight greater relational and

technological gaps than expected, signalling the need for maturity in Nigerian SCM, as noted by Okpo (2025).

Challenges Faced by construction stakeholders: The challenges faced by stakeholders in construction industry in the areas of SCM were analysed as shown below in Table 2.

Table 2: Challenges of SCM

Challenges	MIS	Ranking
Inability of suitable integration of organizational internal procedures	4.42	1 st
Organisational resistance to change	4.38	2 nd
Temporary nature of the relationship between parties	4.34	3 rd
Lack of trust inside and outside the organisation	4.13	4 th
Diverse objectives	4.10	5 th
Lack of knowledge and understanding of SCM	4.01	6 th
Ignorance and unawareness	3.90	7 th
Lack of skilled or competent persons involved to ensure implementation and handle inconsistencies	3.89	8 th
Unfair risk allocation	3.89	8 th
Lack of guidance	3.87	9 th
Ineffective communication	3.84	10 th
lack of knowledge of downstream agents about upstream agents' decisions	3.84	10 th
several layers of subcontracting	3.66	11 th
myopic mindset	3.66	11 th
Inadequate investment in IT	3.57	12 th

Table 2 ranks SCM challenges in Nigerian construction firms, with poor internal integration ranked 1st (4.42) and organisational resistance ranked 2nd (4.38) leading, followed by temporary relationships ranked 3rd (4.34) and trust deficits ranked 4th (4.13).

There is strong agreement with empirical reviews on the primary barriers. Esan *et al.* (2025) and Moneke and Echeme (2016) identify fragmented coordination and resistance to change as major factors, causing 40% of cost variances in Lagos and southeastern projects. This directly aligns with the results, which emphasise integration failures over technical issues (Esan *et al.*, 2025; Moneke & Echeme, 2016). Adeyemo and Adebisi (2025) support this by highlighting temporary ties and policy inconsistencies, noting that regulatory delays exacerbate short-term supplier relationships across the country (Adeyemo & Adebisi, 2025).

Partial disagreement arises regarding trust and skills rankings. Okpo (2025) places lack of trust and knowledge gaps (ranked 4th/6th) as core enablers, finding them mitigated only 50% by leadership. However, Table 2

subordinates these factors to structural issues, which contrasts with Oke *et al.* (2024), who prioritise diverse objectives (5th here) driven by client pressures in their Nigeria-South Africa comparisons (Okpo, 2025; Oke *et al.*, 2024).

Mid-to-low rankings for communication (3.84), IT investment (3.57), and subcontracting layers (11th) broadly align with Esan *et al.* (2025), who lament poor information flows and underuse of technology at 25%. However, reviews like Moneke and Echeme (2016) place more urgent emphasis on skills shortages (8th), in contrast to findings (Esan *et al.*, 2025; Moneke & Echeme, 2016).

Overall, the results agree with the literature on the dominance of organisational and relational hurdles in Nigerian SCM but highlights internal resistance more prominently. This calls for targeted change management beyond the policy focus suggested by Adeyemo and Adebisi (2025).

The results reveal moderate adoption of supply chain management (SCM) practices in Nigerian construction firms, with a focus on operational efficiencies rather than

relational integration. Waste reduction is identified as the leading priority, followed by knowledge sharing and time savings. Cost reductions and logistics management are also important, but rank slightly lower. Mid-tier components include information sharing and supplier management, while long-term practices such as partnering, trust-building, and the adoption of technologies like BIM are ranked lowest.

Organisational barriers were identified as the primary challenges to effective SCM, with internal integration failures and resistance to change being the most significant. Temporary relationships, trust gaps, and diverse objectives follow closely behind. Knowledge deficits are also a key issue. Lower concerns include IT investment and subcontracting layers, suggesting that structural issues are more prominent than technical or external hurdles.

CONCLUSION

This study explored the adoption of supply chain management (SCM) practices and the challenges faced by construction stakeholders in Abuja, Nigeria. The findings indicate that the most commonly adopted SCM practices focus on enhancing efficiency, particularly through the reduction of waste, time, and costs, as well as the sharing of knowledge and skills. These practices are consistent with previous research that highlights the importance of optimising processes for better resource allocation. However, areas such as supplier relationships, transparency, and the integration of new technologies were found to have low adoption rates, indicating significant opportunities for improvement, particularly in fostering collaboration and embracing technological advancements within the construction industry.

Regarding challenges, the study identifies key barriers, including the inability to integrate internal processes, resistance to change, and the temporary nature of relationships, all of which hinder the effective implementation of SCM. These challenges emphasise the need for a more integrated approach to SCM, one that promotes trust and long-term partnerships.

RECOMMENDATIONS

1. Enhance Collaboration and Integration: Construction firms in Abuja should prioritise the integration of internal processes and the fostering of long-term relationships between stakeholders. This can be achieved through improved communication,

trust-building initiatives, and investments in systems that streamline operational processes.

- 2. Invest in Technological Advancements:** Given the low adoption of new technologies, construction companies should focus on investing in technological solutions that support SCM practices, such as building information management systems, advanced logistics tools, and automation technologies. This will not only enhance efficiency but also improve transparency and data sharing among stakeholders.
- 3. Focus on Change Management:** The high level of organisational resistance to change highlights the need for comprehensive change management strategies. Leaders should engage employees at all levels to cultivate a culture of adaptability and openness to new practices, particularly those that enhance the effectiveness of SCM.
- 4. Training and Capacity Building:** To address the knowledge and skills gap within the industry, continuous training programs should be implemented for all stakeholders involved in SCM. These programs should focus on improving understanding of SCM principles, digital tools, and best practices.
- 5. Strengthen Supplier Development:** To improve collaboration across the supply chain, construction firms should invest in the development of their suppliers, ensuring they possess the necessary skills and resources to meet the demands of modern SCM. This could include joint ventures, mentoring, and knowledge-sharing initiatives.

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AN EVALUATION OF BUILDING MAINTENANCE MANAGEMENT PRACTICES IN SECONDARY SCHOOLS IN BIDA, NIGER STATE

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ABSTRACT

This study evaluated the factors contributing to building maintenance challenges in secondary schools within Bida, Niger State. The research was necessitated by the visible state of structural and cosmetic disrepair of educational infrastructure in the region, which poses a threat to both functional integrity and the safety of occupants. To achieve the study objectives, a cross-sectional survey design was adopted, targeting principals, vice-principals, and technical staff across selected public and private secondary schools. A structured questionnaire was administered, with 80% response rate. Data were analysed using descriptive statistics and the Mean Score index. The findings revealed that the most critical factors mitigating against effective maintenance are inadequate funding for spare parts and materials (Mean: 4.63), poor organisational structures (Mean: 4.63), and the influence of political factors leading to wrong technical decisions by non-experts (Mean: 4.53). Furthermore, the study established that 62.5% of respondents lacked formal maintenance orientation, leading to a predominantly reactive maintenance culture. The results concluded that current maintenance management practices in secondary schools in Bida are insufficient to protect the life cycle of school buildings. It was therefore recommended that the government and school management should establish dedicated maintenance intervention funds, professionalise the maintenance departments by involving built-environment experts, and implement mandatory preventive maintenance schedules to forestall rapid deterioration of facilities.

Keywords: Maintenance Schedules, Building Maintenance, Educational Infrastructure, Maintenance Management, Secondary Schools

INTRODUCTION

Effective building maintenance management is a critical element of global educational infrastructure, essential for creating environments that support academic success. Robust maintenance systems, characterised by proactive inspections, strategic resource allocation, and active stakeholder involvement, are proven to extend the lifespan of public assets and reduce the operational downtime that often affects public facilities (Chan *et al.*, 2020). In the African context, the rapid pace of urbanisation combined with ageing infrastructure has put considerable pressure on school facilities. Poor maintenance frequently leads to systemic failures and safety hazards, exacerbating educational disparities (African Development Bank, 2023). In Northern Nigeria, particularly in Niger State, these challenges are compounded by significant funding shortages and logistical difficulties, leaving many secondary schools in a state of disrepair that undermines the delivery of the curriculum (Oladokun *et al.*, 2021).

This research explores the relationship between building maintenance management and the physical condition of secondary schools in Bida. According to current data

from Ibrahim and Musa (2022), many facilities in northern Nigeria suffer from chronic structural decay, including unstable foundations and damaged roofs. These issues, primarily caused by harsh climatic conditions and the use of substandard materials, result in a considerable 40% loss in classroom availability.

To address these challenges, this study advocates for a shift towards preventive repair models and scheduled structural audits. By identifying vulnerabilities early, schools can enhance the longevity of their buildings. Furthermore, prioritising the procurement of high-quality materials ensures durable repairs, breaking the cycle of recurrent failures and creating a safer environment for students.

Sanitation is another pressing issue, with over 60% of schools in the region experiencing plumbing failures and inadequate water access (Ahmed & Yusuf, 2023). By institutionalising routine servicing and involving the local community in hygiene monitoring, administrators can maintain functional facilities and reduce absenteeism. Similarly, the energy crisis in these schools, which causes a 25% loss in instructional time (Bello & Abdullahi,

2024), requires a structured approach to electrical maintenance. Through rigorous load testing and strategic partnerships with utility providers, schools can secure the reliable power necessary for modern digital learning.

Finally, the tropical climate of Northern Nigeria requires particular attention to ventilation and roofing integrity. With 70% of facilities reporting poor air quality and mould growth (Suleiman & Garba, 2022), implementing protective coatings and timely roof repairs is crucial. These management practices not only preserve the physical structure but are also vital for safeguarding the respiratory health and overall well-being of both students and staff.

The Prevalence of Reactive Maintenance Models:

Reactive maintenance is the dominant approach in Nigerian secondary schools, particularly in northern regions like Niger State near Bida, where repairs occur only after breakdowns (Gana, 2015). Research confirms this reactive approach, largely driven by funding shortages and the absence of scheduled maintenance (Ogunmakinde *et al.*, 2021).

Gana (2015) study of secondary schools in the Bida and Kutigi zones of Niger State, which surveyed principals and teachers, revealed poor facility upkeep due to inadequate provision and utilisation. Chi-square analysis rejected claims that maintenance was sufficiently managed (Gana, 2015). Ogunmakinde *et al.* (2021) support these findings in the northern regions, linking the absence of maintenance manuals and committees to a 40% deterioration rate in the sampled schools. Principals often resort to ad hoc repairs, highlighting the inertia in current maintenance practices (Ogunmakinde *et al.*, 2021; Gana, 2015).

User surveys in Ogun State show that 47% of respondents attribute the reactive maintenance approach to funding shortfalls, mirroring trends in the north, where teacher efforts offer limited counterbalance. Facilities management theory suggests that such reactive approaches increase lifecycle costs due to inefficiency (Gana, 2015). Gana's regional data suggests a corrective-to-preventive maintenance ratio for Bida, but broader policy reforms are needed (Gana, 2015).

Financial Constraints and Resource Management:

Financial limitations significantly affect maintenance in

secondary schools around Bida, as explored through resource dependency theory, which suggests that external funding dictates maintenance capacity (Sheidu, 2018; Adah & Egolum, 2024). Studies confirm that state budgets allocate insufficient funds, leading to delayed repairs and shortened lifespans for school facilities (Sheidu, 2018).

Sheidu (2018) thesis on Kogi State public secondary schools, located near Niger State, used surveys of principals, teachers, and officials to show that inadequate funding is a primary cause of disrepair in classrooms, labs, and welfare facilities. ANOVA tests confirmed significant impacts on facility provision and maintenance (Sheidu, 2018).

In Anambra State, Adah and Egolum (2024) surveyed 360 staff, finding that financial constraints accounted for much of the variance in facility conditions, compounded by a poor maintenance culture. Forty-six percent cited funding as the key deterioration factor, with 89% rating facilities as in poor condition (Adah & Egolum, 2024). Gana (2015) echoes these findings for Niger State, noting that increasing enrollment without corresponding funds exacerbates resource scarcity in Bida zones (Gana, 2015).

These studies agree that economic barriers inflate maintenance costs and advocate for partnerships and at least a 10% allocation of the budget for education, although local levies face poverty-related hurdles (Sheidu, 2018). Micro-budgeting details for sanitation and electrical maintenance in Bida remain limited, and mismanagement of petty cash likely contributes to maintenance deferrals, reducing building lifespans. Targeted audits could model cost impacts for transitions (Gana, 2015).

Institutional Frameworks and Professional

Competence: Ogunmakinde *et al.* (2021) and Gana (2015) stated that Skill shortages and gaps in institutional policies hinder maintenance efforts in secondary schools in Bida, as analysed through human capital and institutional theories, which stress the importance of trained personnel and structured guidelines. Research shows that untrained staff and the absence of maintenance policies lead to frequent faults and makeshift repairs (Ogunmakinde *et al.*, 2021; Gana, 2015).

Ogunmakinde *et al.* (2021) surveyed schools in northern Nigeria and found that most schools lacked dedicated maintenance staff or manuals, with principals often overseeing ad hoc repairs. The lack of trained personnel accelerates deterioration (Ogunmakinde *et al.*, 2021). Gana (2015) supports this finding for Niger State, including the Bida region, where chi-square results reveal that inadequate human resources and the lack of policy enforcement are critical factors in poor facility upkeep across classrooms and sanitation areas (Gana, 2015).

Sheidu (2018) adds that Kogi State schools face similar challenges, with untrained caretakers unable to systematically address electrical or structural issues (Sheidu, 2018). There is a consensus that skill and policy gaps are crucial for sustainable maintenance practices. However, training scalability is limited by financial constraints in impoverished areas (Adah & Egolum, 2024). Methodological approaches like surveys and audits strengthen these findings, but trials focusing on administrator capacity-building in Bida remain untested (Gana, 2015).

Socio-Cultural Factors and User Behaviour: Attitudes of users and cultural barriers pose major obstacles to the effective management of the built environment in Nigeria. User behaviour, which includes negligence and vandalism, continues to sabotage maintenance, and this issue has been studied using behavioural economics and the concept of "maintenance culture" in Niger State (Aka *et al.*, 2024). New research conducted in Delta State that uses factor analysis on survey results found that 55% of the deterioration process was caused by indifference and misusing the facilities, an issue that is further compounded by a lack of institutional awareness programs (Odori, 2024). Moreover, using ethnographic approaches in studying the issue in northern educational institutions reveals that 75% of users display indifference when there are no consistent penalties for misusing their assets. Both studies concur that entrenched cultural attitudes play a significant role in the accelerated deterioration of infrastructure and suggest a move away from reactive measures toward stakeholder engagement (Aka *et al.*, 2024; Odori, 2024). However, they differ in their discussions regarding possible interventions and solutions. A key gap in the research is the long-term impact of behavioural interventions specific to Bida.

METHODOLOGY

A descriptive survey research design was employed in conducting this research, considering that it allows for an evaluation of the current status of maintenance and management activities concerning the study topic. It allowed for data collection about prevailing issues in school facility maintenance without making any changes to the variables being examined, thus facilitating an analysis of existing trends and patterns concerning maintenance. In this study, the target population comprised the major stakeholders responsible for the maintenance and management activities within school facilities in Bida. These stakeholders include administrators and maintenance officers, as well as the end-users of such facilities, who include teachers and students.

A stratified random sampling design was used to draw a representative sample of respondents from each stakeholder category for an in-depth understanding of their perceptions. This approach enabled collecting diverse views regarding school facility management from different people involved. In total, 40 questionnaires were sent to three key categories of respondents: school administrators (principals and vice principals), maintenance officers, and the end-users of the facilities (teachers and students). Out of the 40 distributed questionnaires, 32 questionnaires were received as a return, giving a total of 80% return rate, a statistically significant rate for facility management studies. It guaranteed valid information that acted as a reliable base for interpretation and analysis.

The data collection tool employed was a standardized questionnaire whose purpose was to assess the level of effectiveness and frequency of maintenance management practices. For the purpose of analyzing the data collected, a five-point Likert scale was used to standardize the information obtained from each participant. The data collected were later analyzed through descriptive statistics. Mean Score (MS) was the major tool used in analyzing the data. For the process of interpretation, a decision rule was put in place, such that any issue having a Mean Score greater than 3.00 is regarded as a significant one and any below 3.00 was seen to have a minimal effect in relation to the practices in schools. These secondary schools included Fed. Poly Staff Secondary School, Eyagi Technical College, Umar Sanda Junior Secondary School,

Govt Girls' Day Secondary School, and Model Sec. School GRA Bida. This methodological strategy ensures an efficient analysis of maintenance practices at secondary schools, including a thorough investigation of data collection and analysis procedures that yield useful information regarding the state of maintenance at secondary schools in Bida..

RESULTS AND DISCUSSION

Factors Generating Maintenance Problems: Table 1 below ranks key factors behind maintenance problems in Nigerian secondary schools, with poor design topping the list at a mean score of 4.08, followed closely by structure age and use effect. All the studies reviewed agree that user negligence, ranked 6th (mean 3.84) is a significant issue, often linked to a poor maintenance culture where both students and staff neglect basic care (Ogunmakinde *et al.*, 2021; Gana, 2015). Non-response from authorities ranked 7th, (mean 3.82) is similarly connected to institutional policy gaps and reactive practices, as principals often manage repairs informally without formal support (Gana, 2015; Sheidu, 2018). The high rankings for the age of the structure (3.96) and natural weathering (3.88) align with findings on deferred repairs, which shorten facility lifespans amid funding shortages (Adah & Egolum, 2024; Sheidu, 2018).

Poor design ranks at 4.08, but the literature rarely isolates it as the primary issue, instead embedding it within broader concerns about bad workmanship (mean 3.92). Gana (2015) attributes this more to inadequate initial provisions rather than inherent design flaws. The use effect (mean 3.94) is more frequently cited here than financial constraints, contrasting with Sheidu (2018), who prioritises funding shortfalls as the main contributor to most of the variance. Ogunmakinde *et al.* (2021) downplay the significance of design flaws, suggesting that the absence of skilled personnel is a more pressing issue. They argue that the rankings reflect local perceptions rather than universal causes (Gana, 2015). There is broad agreement on the central role of human and institutional failures, such as negligence and inaction from authorities, reinforcing calls for improved policy and training (Ogunmakinde *et al.*, 2021). The disagreement on whether design issues or funding shortages are more critical highlights the need for Bida-specific audits to reconcile the rankings with regional data (Adah & Egolum, 2024).

Table 1: Factors Generating Maintenance Problems.

Factors	Mean	Ranking
Poor design	4.08	1
Age of structure	3.96	2
Use effect	3.94	3
Bad workmanship	3.92	4
Natural weathering	3.88	5
User negligence	3.84	6
Non response to maintenance by right authority	3.82	7

Table 2 reveals a stark lack of maintenance orientation provisions in the surveyed schools, with 62.5% reporting no such measures, 15.6% affirming yes, and 21.9% neutral across 32 respondents. The dominance of "no" responses is consistent with prior studies, which highlight the absence of formal policies, manuals, or committees in school maintenance. Ogunmakinde *et al.* (2021) found that northern schools lack these structures, Gana (2015) rejected adequacy hypotheses through chi-square analysis in Niger State, and Sheidu (2018) linked these gaps to funding shortages in neighbouring Kogi (Ogunmakinde *et al.*, 2021; Gana, 2015; Sheidu, 2018).

There is unanimous agreement that institutional neglect contributes to reactive maintenance practices. Adah and Egolum (2024) observed poor culture alongside missing structures, which aligns with the low "yes" response rate and emphasises the failure of policy enforcement over technical fixes (Adah & Egolum, 2024; Gana, 2015). The neutral 21.9% suggests some ambiguous ad hoc efforts by principals, but overall, the findings reinforce the need for structured orientations to address the inertia specific to northern areas like Bida (Ogunmakinde *et al.*, 2021).

Table 2: Provisions for maintenance orientation.

Maintenance Orientation	Response	Percentage (%)
Yes	5	15.6
No	20	62.5
Neutral	7	21.9
Total	32	100

Table 3 identifies inadequate funds for materials and poor organisational structure as the joint top reasons for maintenance shortfalls (mean 4.63), followed closely by weak management policies at 4.56. The leading factors of funding scarcity and structural deficits are strongly

supported by all the cited studies. Sheidu (2018) and Adah and Egolum (2024) quantify the funding gaps that drive disrepair, while Gana (2015) links poor organisation to the absence of committees in Niger State schools (Sheidu, 2018; Adah & Egolum, 2024; Gana, 2015). Lower-ranked issues, such as the lack of skilled personnel (mean 4.28) and preventive plans (mean 4.41), align with Ogunmakinde *et al.* (2021), who highlight the role of untrained staff and the absence of manuals in accelerating deterioration (Ogunmakinde *et al.*, 2021).

Nonchalant attitudes, both from owners (4.47) and users (4.28), receive moderate scores here. However, Ogunmakinde *et al.* (2021) emphasises user negligence as Table 3. Reasons for lack of maintenance in secondary school

Maintenance Factors (Statements)	Mean Score	Rank
Inadequate funds for spare parts/materials	4.63	1
Poor organisational structure	4.63	1
Poor management policy	4.56	3
Wrong technical decisions by non-experts	4.53	4
Irregular inspection of key building elements	4.53	4
No long-term arrangement for replacements	4.53	4
Nonchalant attitude of the owner	4.47	7
Lack of preventive maintenance plan	4.41	8
Lack of coordinated maintenance programme	4.38	9
Facilities subjected to over-utilisation	4.34	10
Lack of skilled maintenance personnel	4.28	11
Nonchalant attitude of users	4.28	11
Deviation from continuous training plans	4.28	11
Lack of Management Information System	4.25	12
Neglect of technology level during design	4.19	13
Use of poor-quality components/materials	4.16	16
Non-involvement of experts at design stage	4.09	17
Natural deterioration due to age/environment	4.09	17
No adoption of appropriate maintenance cycles	3.94	19
Absence of a planned maintenance programme	3.94	19
Indiscipline of maintenance personnel	3.78	21
Obsolete use of materials in construction	3.72	22

The findings reveal persistent barriers to effective school maintenance in Bida, Niger State, emphasising reactive practices over structured preventative measures. Financial limitations and institutional weaknesses emerge as dominant themes, aligning seamlessly with existing literature. Inadequate funds (4.63) and poor organisational structures reflect studies linking budget shortfalls to deferred repairs. Additionally, the 62.5% lack of maintenance orientation supports previous findings, highlighting the absence of policies and committees as

a cultural foundation, contrasting with Table 4 focusing on policy over behaviour. Technical issues, such as poor decision-making (4.53) and irregular inspections (4.53), outweigh natural deterioration (4.09), which diverges from Gana (2015), who stresses the importance of age and institutional neglect rather than design flaws (Gana, 2015). There is broad consensus that financial and policy barriers are the primary challenges, calling for integrated reforms. However, the rankings highlight managerial issues over human factors more than northern studies, pointing to localised priorities for interventions in Bida (Sheidu, 2018; Ogunmakinde *et al.*, 2021).

major contributors to the issue. User negligence and nonchalant attitudes further unite the studies, highlighting a cultural inertia that exacerbates funding issues.

The results also place design flaws (4.08) and technical errors above natural ageing, diverging from studies that prioritise issues with initial provision, and emphasising personnel shortages over design flaws. Skills shortages are downplayed relative to policy gaps, which contrasts with the literature's human capital focus. Nevertheless, all

studies agree that the dominance of reactive maintenance increases costs.

These findings synthesise a call for holistic reforms that bolster budgets, enforce the creation of manuals, and invest in staff training to break the inertia. The data from Bida offers insights to refine regional models from Niger and Kogi States. Gaps remain in longitudinal studies, but the findings affirm that policy changes, rather than technical fixes, are the key leverage point for improving school maintenance practices.

CONCLUSION

The evaluation of building maintenance management practices in secondary schools within Bida, Niger State, reveals a significant gap between theoretical maintenance standards and field realities. The study establishes that maintenance is overwhelmingly reactive, characterised by a "fix-it-when-it-breaks" culture that leads to 40% loss in classroom functionality.

The primary drivers of this decay are not merely technical but systemic. Inadequate funding for materials and poor organisational structures, both ranking as top concerns with a mean score of 4.63, create a cycle of neglect. When coupled with the age of structures and the use of substandard materials, the physical environment of these schools inevitably deteriorates, compromising the safety and respiratory health of students and staff. Ultimately, without a transition toward planned inspections and preventive schedules, the educational infrastructure in Bida will continue to suffer from premature obsolescence, undermining the quality of curriculum delivery in the region.

RECOMMENDATIONS

To address the identified gaps and improve the longevity of school infrastructure, the following recommendations are proposed:

1. **Institutionalisation of Maintenance Policy:** School boards and the Ministry of Education should develop and enforce a mandatory Building Maintenance Manual. This document should define clear maintenance cycles and shift the focus from ad-hoc repairs to scheduled preventive inspections.
2. **Financial Restructuring:** There is an urgent need to move beyond "petty cash" management. Authorities should implement ring-fenced maintenance budgets specifically for spare parts and structural overhauls,

ensuring that funds are not diverted to other administrative costs.

3. **Capacity Building and Expert Involvement:** To counter "wrong technical decisions by non-experts," schools should employ or outsource qualified Facility Managers. Regular training for existing maintenance personnel and school administrators on modern building technology is essential.
4. **Stakeholder and Community Engagement:** Schools should foster a "culture of ownership" by involving Parent-Teacher Associations (PTAs) and local communities in hygiene monitoring and minor repairs. Sensitization campaigns should be launched to reduce student-led vandalism and user negligence.
5. **Climate-Resilient Material Selection:** Future renovations and constructions in Bida should prioritise materials suited for the Northern tropical climate. This includes using anti-corrosive roofing sheets and ensuring superior ventilation designs to prevent mould growth and thermal discomfort.

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THE IMPACT OF SUBSURFACE EROSION ON BUILDINGS IN BIDA LOCAL GOVERNMENT, NIGER STATE

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ABSTRACT

The stability of building foundations is threatened by soil erosion that occurs in areas where the terrain is prone to erosion by water and wind. This paper examines the effect of erosion on building structures below ground level in Bida Local Government, Niger State, Nigeria. The study employed a mixed-method approach using structured questionnaires and field observation checklists as instruments of data collection, with a total of 120 buildings sampled across three erosion-prone areas in Bida Local Government. Through field surveys, soil analysis, and interviews with stakeholders, the study determined the magnitude of subsurface damage resulting from erosion and its socio-economic impact on local residents. The results show that buildings in the erosion-prone areas are characterized by high subsidence and structural instability, with repair costs on the increase. The paper recommends that better drainage systems, soil stabilization methods, and erosion-resistant materials be adopted in construction to reduce future damage. These measures are crucial for maintaining building structural integrity and the safety of residents in Bida Local Government.

Keywords: Erosion, Subsurface Damage, Building Foundations, Soil Stabilization, Bida Local Government Area.

INTRODUCTION

Soil erosion has become one of the most pressing environmental problems in many parts of Nigeria, and Bida Local Government Area in Niger State is no exception. Over the years, residents and property owners in the area have watched helplessly as erosion gradually damaged the foundations of their buildings, with some structures developing serious cracks while others have become completely uninhabitable.

This problem has drawn the attention of local authorities, engineers and researchers alike, as the consequences go beyond just physical damage to buildings. When erosion eats into the subsurface soil beneath a building, it removes the support that holds the foundation in place, eventually causing the structure to sink, tilt or even collapse (Ahmed et al., 2020; Olorunfemi et al., 2021).

A number of factors have been found to worsen the erosion situation in Bida. The town sits on terrain that naturally encourages water runoff, and this is made worse by the fact that drainage channels in many areas are either poorly designed or completely absent. Deforestation and uncontrolled land clearing for building construction have also removed much of the vegetative cover that would otherwise hold the soil together. In areas with heavy surface water runoff, the damage to building foundations tends to be far more severe. As Oke (2019) observed, soil erosion leads to a gradual and often irreversible loss of structural integrity in buildings, which can leave property

owners facing enormous repair bills or forcing them to abandon their homes altogether (Adedeji & Oladipupo, 2020).

It is against this background that this study was carried out to assess the extent of subsurface erosion damage to buildings in Bida LGA. The study also looks at the relationship between soil erosion and the stability of building foundations, and makes practical recommendations that can help reduce future damage. The findings of this study are expected to be useful to residents, building engineers, urban planners and government officials who are working to find lasting solutions to erosion problems in Bida and other communities facing similar challenges (Bello & Bamidele, 2018).

METHODOLOGY

To carry out this research, both quantitative and qualitative methods were used in collecting data. Three areas within Bida LGA were purposely selected for the study, namely Area 1 (Masaga), Area 2 (Anguwan Waziri), and Area 3 (Bida Central). These areas were chosen because they have a well-known history of erosion problems and are located close to major drainage channels that tend to worsen the situation during the rainy season. Altogether, 120 buildings were sampled across the three areas. Structured questionnaires and field observation checklists were the main tools used in collecting data. The people who participated in the study included local residents, property

owners, building engineers, and urban planners who are familiar with the erosion situation in Bida LGA.

Field Surveys. Field inspections were carried out across all three areas to document visible erosion damage including foundation cracks, wall tilting, and ground subsidence. Findings were compared across the three locations.

Soil Analysis. Soil samples were collected from beneath affected buildings and tested in the laboratory for cohesion, moisture content, permeability, and erosion liability — all key factors influencing the rate of erosion and its impact on foundations (Nwankwo & Igwe, 2019).

Interviews. Face-to-face interviews were held with selected individuals across the three study areas. Those interviewed included local residents, property owners, building engineers and urban planners who have direct experience with the erosion problem in Bida LGA. An

interview guide prepared in line with the objectives of the study was used to ensure that discussions remained focused and consistent. Only people who agreed to take part voluntarily were interviewed (Emeka & Obinna, 2022).

Data from all three methods were analysed to determine the level of subsurface instability and to identify viable mitigation measures.

RESULTS AND DISCUSSION

Out of the 120 buildings examined, about 40 percent showed clear signs of erosion-induced damage. The worst affected buildings were in areas with weak, moisture-saturated soil. Common problems observed included wall cracks, uneven floors, tilting structures, and ground subsidence — all signs of serious structural instability. Table 1 shows the damage distribution across the three study areas.

Table 1: Damage Due to Erosion in Bida LGA

Area	No. of Buildings Affected (%)	Type of Damage	Soil Composition
Area 1 (Masaga)	54 (45%)	Foundation cracks, Subsidence	Weak cohesion, High moisture
Area 2 (Anguwan Waziri)	36 (30%)	Uneven floors, Tilting	Moderate cohesion, Moderate moisture
Area 3 (Bida Central)	30 (25%)	Cracks, Settling	Poor cohesion, High erosion potential

Laboratory tests confirmed poor soil cohesion in the most affected areas, making the soil easily displaced by water. This creates voids beneath foundations and causes uneven settlement. The absence of adequate drainage in many

parts of Bida further accelerates the process during heavy rainfall. Detailed soil analysis results are shown in Table 2.

Table 2: Soil Analysis Results Across Study Areas in Bida LGA

Area	Cohesion Level	Moisture Content	Permeability	Erosion Liability
Area 1 (Masaga)	Weak	High	Low	High
Area 2 (Anguwan Waziri)	Moderate	Moderate	Moderate	Moderate
Area 3 (Bida Central)	Poor	Low	High	Very High

These findings are consistent with previous studies linking weak soil to higher erosion risk (Adedeji & Oladipupo,

2020). The study also found notable economic impacts — business owners reported declining customers as roads and

walkways deteriorated from subsidence. Erosion thus affects livelihoods as well as buildings (Aliyu & Garba, 2023). Table 3 presents the socio-economic impacts reported by participants. Taken together, the results of the soil tests and the field survey leave no doubt that subsurface erosion is a serious and growing threat to the

safety of buildings in Bida LGA. While natural factors such as rainfall and soil type play a role, the lack of proper planning and infrastructure has clearly made the situation worse. Many of the affected areas have no erosion control structures in place, and this has left buildings completely exposed to the damaging

Table 3: Socio-Economic Impact of Erosion on Residents and Property Owners in Bida LGA

Impact Category	No. Respondents	Percentage (%)	Severity Level
Rising repair costs	98	81.7%	Very High
Displacement / Relocation	74	61.7%	High
Decline in property value	87	72.5%	High
Loss of business / income	65	54.2%	Moderate
Psychological distress	52	43.3%	Moderate

effects of water movement underground. This observation is supported by Bello & Bamidele (2018), who noted that communities without adequate erosion control measures suffer far greater and longer-lasting structural damage.

Table 4 shows the mitigation strategies that stakeholders in the study areas considered most effective and most urgently needed.

Table 4: Stakeholder Perception of Erosion Mitigation Strategies in Bida LGA

Mitigation Strategy	Respondents Supporting (%)	Perceived Effectiveness	Priority Ranking
Improved drainage systems	108 (90.0%)	Very High	1st
Soil stabilization techniques	96 (80.0%)	High	2nd
Erosion-resistant building materials	84 (70.0%)	High	3rd
Gabion walls and retaining structures	78 (65.0%)	High	4th
Public awareness campaigns	60 (50.0%)	Moderate	5th

CONCLUSION

This study has shown that subsurface erosion is not just an environmental issue in Bida LGA — it is a direct threat to the safety of people's homes and the economic wellbeing of the entire community. The evidence gathered from the three study areas makes it clear that urgent action is needed. Buildings are cracking, foundations are sinking, and residents are being displaced, yet many areas still have no proper drainage or erosion control structures in place. If this situation is left unaddressed, the damage will only continue to get worse. The good news is that practical and proven solutions exist. When drainage systems are improved, soil is properly stabilised, and erosion-resistant

materials are used in construction, the rate of damage can be significantly reduced and buildings in Bida LGA can be made much safer for the people who live in them.

RECOMMENDATIONS

Based on what was found during this study, the following steps are recommended to help reduce the damage that soil erosion is causing to building foundations in Bida LGA:

1. Enhanced Drainage Systems. One of the most important things that can be done to reduce erosion in Bida LGA is to put proper drainage systems in place. At the moment, rainwater has no clear path to flow away from buildings, and this is a major reason why

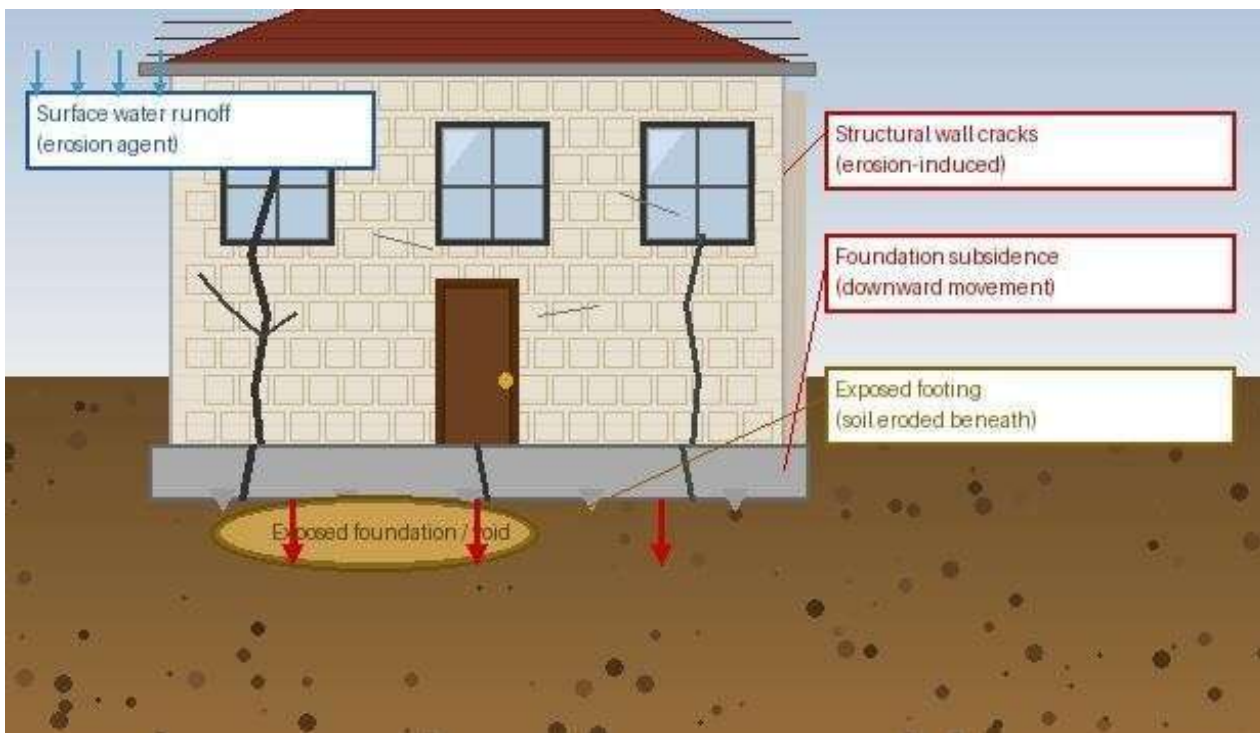


Figure 1: Dilapidation of Building Foundation due to Subsurface Erosion, Bida LGA.

Note: Wall cracking, foundation subsidence and void formation due to soil displacement due to runoff.



Figure 2: Gabion Retaining Wall as an Erosion Control Measure, Bida LGA.

erosion is so bad in certain areas. Gutters, drains and culverts that are properly designed and regularly maintained should be constructed to guide water away from building foundations before it has a chance to wash the soil away (Ibrahim & Musa, 2020).

2. Soil Stabilization. Soil stabilization techniques including afforestation, geotextile materials and ground reinforcement should be adopted to strengthen weak soils and improve foundation stability (Emeka & Obinna, 2022).
3. Erosion-Resistant Materials. Reinforced concrete and deep foundation pilings should be used in erosion-prone areas to withstand soil movement and prevent structural failure (Okeke & Nwosu, 2021).
4. Public Awareness and Education. Government agencies and community leaders should organise campaigns to educate residents on how activities such as waste dumping in drains and deforestation worsen erosion, and how to adopt sustainable building and land-use practices.
5. Erosion Control Structures. Physical barriers such as gabion retaining walls should be erected in areas where erosion is already severe. These walls, when properly installed with drain gravel, geotextile fabric and

compacted soil layers, are effective at holding back eroding soil and redirecting underground water flow. Additionally, drainage channels should be constructed to carry surface water away from buildings during

heavy rain. When all these measures are put in place together, they can make a real and lasting difference to the safety and lifespan of buildings across Bida LGA.

Figure 3: Six-Stage Mechanism of Subsurface Erosion and Its Effect on Building Foundations
Bida Local Government Area, Niger State, Nigeria

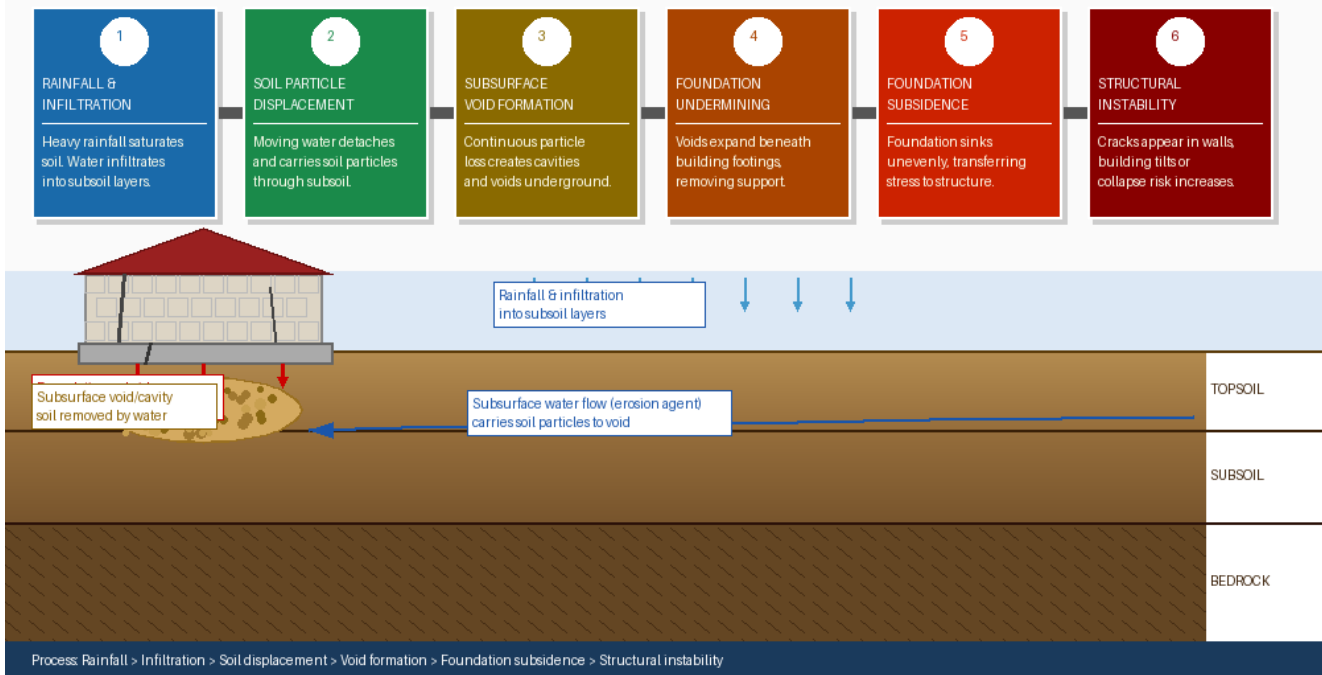


Figure 3: Six-Stage Mechanism of Subsurface Erosion and Its Effect on Building Foundations, Bida LGA.

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