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Assessing Sustainable Architectural Designs in Tropical Climates, Contextual Strategies for Nigerian Architects

Okor Michael Uduma

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Department of Architecture, Abia State University, Uturu, Nigeria.Email: michael.okor@abiastateuniversity.edu.ng

ABSTRACT

This study investigates sustainable architectural design practices in Nigeria's tropical climate, focusing on contextual strategies for effective implementation. The study evaluated current sustainable design practices in Nigerian architecture, identified climate-responsive strategies suitable for Nigeria's tropical climate, and proposed guidelines for integrating sustainable design principles into Nigerian architectural education and professional practice in Nigeria. A mixed-methods approach, comprising surveys and interviews with 210 architects and engineers, was employed to assess awareness, adoption, and the factors influencing sustainable design strategies. The results show that natural ventilation had the highest awareness rate (90.5%), followed by solar control (85.7%), local materials (81.0%), and rainwater harvesting (76.2%). Despite these high awareness levels,, adoption rates were lower, suggesting the presence of barriers such as high implementation costs, limited technical expertise, and other practical constraints . Correlation analysis indicated that years of experience were positively correlated with the adoption of sustainable design strategies, with natural ventilation exhibiting the strongest relationship ($r = 0.45$, $p = 0.001$). Furthermore, multiple regression analysis showed that awareness ($\beta = 0.50$, $p = 0.001$), years of professional experience ($\beta = 0.30$, $p = 0.005$), and geographic location ($\beta = 0.20$, $p = 0.010$) were significant predictors of the adoption of sustainable design strategies. . The study concludes that Nigeria's built environment is expanding rapidly in response to the growing demand for residential, commercial, and institutional buildings. his rapid growth underscores the need to adopt sustainable design principles that are tailored to the country's unique environmental, climatic, and socio-economic context. Nigeria's tropical climate, characterized by high temperatures, intense solar radiation, high humidity, and seasonal heavy rainfall, requires climate-responsive architectural solutions that enhance occupant comfort while minimizing environmental impacts. Achieving sustainable design therefore requires the integration of context-specific strategies that reflect local climatic conditions, cultural preferences, available resources, and economic realities. Such an approach will promote the development of resilient, resource-efficient, and environmentally responsible buildings that effectively respond to Nigeria's ecological and socio-cultural needs while supporting long-term sustainable development.

Keywords: Sustainable design, tropical climate, contextual strategies, natural ventilation, climate-responsive strategies.

INTRODUCTION

Sustainable architecture is essential in Nigeria's tropical climate, where high temperatures, intense solar radiation, high humidity, and seasonal heavy rainfall present significant challenges to building performance and occupant comfort. Rapid urbanization and population growth have further increased the demand for residential, commercial, and institutional buildings, placing considerable pressure on natural resources and contributing to environmental degradation. These challenges underscore the urgent need to adopt sustainable design principles that promote energy efficiency, resource conservation, environmental protection, and climate resilience. Integrating climate-responsive architectural strategies into building design is therefore critical to reducing environmental impacts, improving indoor environmental quality, and supporting sustainable development in Nigeria's built environment. (Adebayo and Ojo, 2018). Nigeria's tropical climate, characterized by high temperatures, intense solar radiation, and seasonal heavy rains, demands careful consideration in architectural design (Olotuah, 2017). The country's building sector is expanding rapidly due to urbanization and economic development, resulting in increased energy consumption, greenhouse gas emissions, and greater pressure on natural resources (Ezenwa and Okoye, 2020). For instance, buildings in Nigeria account for approximately 40% of the country's total energy consumption, underscoring the urgent need for sustainable design practices.. Effective sustainable design in Nigeria requires contextual strategies that address local climate conditions, cultural preferences, and resource constraints (Akinwumi, 2019). Key considerations for sustainable architecture in Nigeria include natural ventilation and passive cooling, solar control and shading, rainwater harvesting and management, and the use of locally sourced and sustainable building materials (Akinwumi, 2019). However, the adoption of sustainable design

principles in Nigeria remains constrained by several factors, including limited awareness, high initial implementation costs, inadequate technical expertise, and weak regulatory frameworks (Ogunbiyi, 2022). Climate change is expected to intensify Nigeria's environmental challenges, including flooding, droughts, and heatwaves, with significant consequences for human health, infrastructure, and economic development (IPCC, 2022). Moreover, the unsustainable use of energy and natural resources in the building sector contributes substantially to greenhouse gas emissions, thereby accelerating climate change and increasing environmental degradation (UNEP, 2020).

This study assesses sustainable architectural designs in tropical climates, focusing on contextual strategies for Nigerian architects. The objectives are to evaluate current sustainable design practices in Nigerian architecture, identify climate-responsive strategies suitable for Nigeria's tropical climate, and propose guidelines for integrating sustainable design principles in Nigerian architectural education and practice (Babalola et al., 2024; Cassaignau and Jung, 2025). This research provides architects, policymakers, and other stakeholders in Nigeria with valuable insights into climate-responsive design strategies, thereby contributing to the development of more sustainable, resilient, and comfortable built environments in Nigeria and other tropical regions.

LITERATURE REVIEW

Theoretical Framework

The study, sustainable architectural design in tropical climates, particularly Nigeria, is underpinned by Ecological Modernization Theory and Social Practice Theory. These complementary theories provide a robust foundation for explaining how environmental sustainability can be achieved through technological innovation while recognizing the influence of social, cultural, and institutional factors on the adoption of sustainable architectural practices.

Ecological Modernization Theory argues that economic development and environmental sustainability are not mutually exclusive but can reinforce one another through technological advancement, policy innovation, efficient resource utilization, and environmentally responsible production systems. Rather than viewing environmental protection as an obstacle to development, the theory suggests that sustainable technologies, improved institutional arrangements, and green innovations can simultaneously stimulate economic growth and reduce environmental degradation (Omopariola et al., 2022). Within the architectural sector, this perspective supports the adoption of energy-efficient building systems, renewable energy technologies, sustainable construction materials, and climate-responsive building designs that minimize ecological footprints while improving building performance. In the Nigerian context, where rapid urbanization has increased pressure on infrastructure and natural resources, Ecological Modernization Theory provides a useful explanation for why architects, policymakers, and developers should embrace sustainable architectural innovations as pathways toward sustainable urban development.

Complementing this perspective, Social Practice Theory emphasizes that sustainable architectural design is not determined solely by technological innovations but is also shaped by everyday social practices, cultural norms, institutional arrangements, professional knowledge, and behavioural patterns. The theory proposes that individuals' decisions and professional practices are influenced by the interaction between materials, competencies, and social meanings embedded within their environments. Consequently, architects' willingness to adopt sustainable design principles depends not only on the availability of sustainable technologies but also on professional training, organizational culture, client preferences, regulatory support, and societal awareness. In Nigeria, where sustainable building practices remain relatively underutilized, Social Practice Theory helps explain how limited awareness, inadequate professional capacity, and weak institutional support continue to constrain the widespread adoption of climate-responsive architecture despite increasing environmental concerns.

Together, Ecological Modernization Theory and Social Practice Theory provide a comprehensive framework for understanding sustainable architectural practice in Nigeria. While Ecological Modernization Theory highlights the technological and policy dimensions necessary for environmental sustainability, Social Practice Theory explains the behavioural and institutional processes that influence the successful implementation of sustainable architectural strategies.

Sustainable Architectural Design in Tropical Climates

Sustainable architecture has become an increasingly important approach to addressing the environmental consequences of rapid urbanization, climate change, and increasing energy consumption. In tropical regions such as Nigeria, sustainable architectural design seeks to optimize building performance by responding appropriately to prevailing climatic conditions while minimizing dependence on non-renewable resources. Unlike conventional architectural approaches that rely heavily on mechanical cooling and artificial lighting, sustainable design emphasizes passive environmental strategies that improve indoor comfort while reducing operational energy demand.

The tropical climate of Nigeria is characterized by high temperatures, elevated humidity, intense solar radiation, and seasonal heavy rainfall. These climatic conditions present unique challenges that require context-specific architectural responses. Buildings that fail to respond adequately to these environmental conditions often experience excessive heat gain, poor indoor air quality, increased cooling loads, and reduced occupant comfort. Consequently, sustainable architecture in Nigeria increasingly focuses on climate-responsive design principles that integrate passive cooling, natural ventilation, daylight optimization, rainwater management, and environmentally friendly building materials (Chen Austin et al., 2024).

Challenges Affecting Sustainable Architectural Design in Nigeria

Despite growing awareness of environmental sustainability, the implementation of sustainable architectural practices in Nigeria remains limited by several interconnected challenges. One of the major barriers is the inadequate understanding of sustainable design principles among construction professionals and clients. Limited professional training and insufficient integration of sustainability concepts into architectural education have contributed to low adoption rates across the construction industry.

Economic factors also constitute significant obstacles.

Sustainable building materials, renewable energy technologies, and energy-efficient systems often require relatively high initial investments, discouraging many developers despite their long-term economic benefits. Ogunbiyi (2022) observed that the perceived high cost of sustainable construction continues to discourage investment in green building technologies. Similarly, Toriola-Coker et al. (2021) identified inadequate financing mechanisms, limited government incentives, and insufficient regulatory enforcement as major impediments to sustainable construction practices in Nigeria. Institutional challenges further constrain implementation. Although sustainability has become a national and global priority, Nigeria lacks comprehensive building regulations and enforcement mechanisms specifically promoting sustainable architectural practices. Weak policy implementation, inconsistent environmental standards, and inadequate monitoring continue to slow the transition toward climate-responsive architecture.

Climate-Responsive Design Strategies

Climate-responsive architectural design represents one of the most effective approaches for improving building performance in tropical climates. These strategies utilize local climatic conditions to reduce energy demand while enhancing occupant comfort and environmental sustainability. Natural ventilation remains one of the most widely recommended passive design strategies for tropical buildings. Proper building orientation, cross ventilation, strategically positioned openings, and stack ventilation facilitate continuous airflow, thereby reducing indoor temperatures and minimizing dependence on air-conditioning systems. According to Babalola et al. (2024), naturally ventilated buildings significantly reduce operational energy consumption while improving indoor environmental quality. Solar control constitutes another essential strategy. Appropriate shading devices, roof overhangs, external louvers, reflective roofing materials, and vegetation reduce direct solar heat gain and improve thermal comfort within buildings. Cassaignau and Jung (2025) reported that effective solar control strategies substantially decrease cooling loads in tropical environments while extending building durability. Rainwater harvesting has also emerged as a critical sustainability strategy for tropical regions experiencing seasonal rainfall variability. Proper rainwater collection, storage, and reuse reduce dependence on municipal water supplies while minimizing stormwater runoff and urban flooding. These integrated water management systems contribute significantly to resource conservation and climate resilience in rapidly urbanizing cities (Babalola et al., 2024).

Vernacular Architecture and the Use of Local Materials

Traditional Nigerian architecture offers valuable insights into climate-responsive design. Before the widespread adoption of modern construction technologies, indigenous buildings successfully utilized locally available materials and passive environmental strategies to achieve thermal comfort under tropical climatic conditions. Features such as thick earthen walls, internal courtyards, verandas, shaded openings, and high ceilings effectively moderated indoor temperatures without mechanical cooling. Pan et al. (2024) argued that vernacular architecture demonstrates the effectiveness of integrating local knowledge with environmental adaptation.
Similarly, Onyia (2023) observed that locally sourced materials such as laterite, adobe, bamboo, timber, and compressed earth blocks possess excellent thermal properties while reducing embodied energy associated with transportation and industrial production. Adetoro and Gambo (2025) further emphasized that these materials are biodegradable, economically affordable, and environmentally sustainable, making them particularly suitable for climate-responsive construction in Nigeria. The renewed interest in indigenous building technologies reflects growing recognition that sustainable architecture should combine modern innovations with traditional environmental knowledge to produce contextually appropriate design solutions.

Principles of Sustainable Architectural Design in Nigeria

Effective sustainable architectural design within Nigeria requires careful integration of environmental, economic, and socio-cultural considerations. Architects must consider prevailing climatic conditions, local building traditions, material availability, user preferences, and economic realities throughout the design process. Akinwumi (2019) emphasized that successful sustainable architecture in Nigeria depends largely on integrating passive cooling systems, efficient solar control measures, rainwater harvesting technologies, and locally sourced building materials. Chen Austin et al. (2024) similarly argued that climate-responsive building envelopes, optimized building orientation, energy-efficient construction methods, and environmentally responsible material selection collectively improve building performance while reducing environmental impacts. These principles not only reduce operational energy consumption but also improve occupant health, indoor comfort, resource efficiency, and long-term building resilience.

Sustainable Architectural Projects in Nigeria

Although sustainable architecture is still emerging within Nigeria, several notable projects demonstrate its practical feasibility. Developments such as the African Alliance Climate-Smart Agriculture Project and Eko Atlantic City have incorporated renewable energy technologies, efficient resource management systems, recycled construction materials, and environmentally conscious planning approaches (Heritage Place, 2024). These projects illustrate how sustainable architectural principles can be successfully integrated into contemporary Nigerian developments despite existing institutional and economic challenges. Such initiatives provide practical examples that encourage wider adoption of climate-responsive architectural practices while demonstrating the economic and environmental benefits of sustainable construction.

Research Gap

Existing literature has extensively examined sustainable building technologies, passive environmental design strategies, and the environmental benefits of climate-responsive architecture. However, relatively few studies have comprehensively investigated the contextual factors that influence the adoption of sustainable architectural practices among Nigerian architects. Kollmuss and Agyeman, 2002 and Diugwu et al. (2021) noted that cultural values, regional climatic variations, institutional capacity, client perceptions, and professional competencies remain insufficiently explored within the Nigerian context. Furthermore, empirical evidence

regarding the economic feasibility, implementation barriers, and long-term performance of sustainable architectural strategies in different regions of Nigeria remains limited. Existing studies have largely focused on technical design solutions while giving less attention to behavioural, institutional, and socio-cultural determinants of adoption. Consequently, there is a need for research that integrates climatic, cultural, economic, and professional considerations to develop context-specific strategies capable of enhancing the implementation of sustainable architectural design in Nigeria. The present study addresses this gap by assessing sustainable architectural designs in tropical climates and proposing contextual strategies that can improve the adoption of sustainable design practices among Nigerian architects.

RESEARCH METHODOLOGY

This study employed a mixed-methods research design, integrating qualitative and quantitative approaches to provide a comprehensive understanding of sustainable architectural design practices in Nigeria's tropical climate, focusing on the contextual strategies for Nigerian architects (Akinwumi, 2019; Ogunbiyi, 2022). The methodological choice was justified by the need to capture both the complexity of contextual factors influencing sustainable design and the breadth of current practices among Nigerian architects. The research design involved a comprehensive literature review, surveys, and case studies of sustainable architecture projects in Nigeria.

Qualitative Method

The qualitative component of the study employed semi-structured interviews with a purposively selected group of architects, engineers, and other stakeholders involved in sustainable building projects in Nigeria. Participants for the interviews were drawn from the overall study sample of 250 respondents to obtain in-depth insights into sustainable architectural practices, implementation challenges, and contextual factors influencing design decisions (Babalola et al., 2024). The interviews provided rich information on participants' experiences, perceptions, and recommendations regarding the adoption of sustainable architectural design in Nigeria. The qualitative data were analyzed using thematic analysis, which involved coding interview transcripts, identifying recurring themes, and interpreting patterns related to sustainable design practices, implementation challenges, opportunities, and context-specific strategies. The findings complemented the quantitative results by providing deeper explanations for the observed trends and relationships.

Quantitative Method

The quantitative component of the study utilized a structured questionnaire survey administered to architects and engineers involved in sustainable building projects across Nigeria. The questionnaire was designed to collect data on awareness, adoption, challenges, and contextual strategies relating to sustainable architectural design (Babalola et al., 2024; Cassaignau and Jung, 2025). A total of 250 questionnaires were distributed, of which 210 were correctly completed and returned, representing a response rate of 84%. The quantitative data were analyzed using descriptive statistics, including frequencies, percentages, and mean scores, to describe respondents' characteristics and assess awareness, adoption levels, and perceived challenges. Inferential statistical techniques, including correlation and multiple regression analyses, were also employed to examine the relationships between selected variables and identify the factors influencing the adoption of sustainable architectural design strategies.

Data Analysis

The study adopted a mixed-methods approach to provide a comprehensive assessment of sustainable architectural design practices in Nigeria. Quantitative data were analyzed using descriptive statistics (frequencies, percentages, and mean scores) and inferential statistics, including correlation and multiple regression analyses. Qualitative data were analyzed using thematic analysis to identify recurring themes and patterns related to sustainable design practices, implementation challenges, opportunities, and contextual factors influencing sustainable architecture in Nigeria.

The integration of quantitative and qualitative findings enabled a more comprehensive understanding of sustainable architectural practices by combining statistical evidence with participants' lived experiences. The results were interpreted in relation to the existing literature and the theoretical framework, with implications drawn for architectural practice, policy formulation, and sustainable development in Nigeria (Babalola et al., 2024; Cassaignau and Jung, 2025).

RESULTS

The study's findings reveal a complex landscape of sustainable design practices in Nigeria's architectural sector. This section analyzes the study's objectives including the awareness, adoption, and challenges associated with sustainable design strategies.

Respondents' Profile

Table 1 presents the demographic characteristics of the respondents, including their profession, location, and years of experience. In terms of profession, the majority of the respondents are architects (57.1%), while engineers make up 42.9%. This suggests that architects are more likely to be involved in sustainable building projects in Nigeria, which is consistent with their role in designing and overseeing construction projects.

The respondents are from various locations across Nigeria, with the majority from Lagos (23.8%) and Abuja (19.0%). These cities are major urban centers and hubs for construction activities in Nigeria, which explains the higher representation from these locations. The respondents from other locations, such as Kano, Calabar, and Port-Harcourt, also contribute to the diversity of the sample, providing insights into sustainable building practices in different regions of Nigeria.

In terms of years of experience, the majority of the respondents have 6-10 years of experience (38.1%), followed by those with 1-5 years of experience (28.6%). This suggests that the respondents have a moderate level of experience in the construction industry, which is likely to influence their understanding and adoption of sustainable design strategies. The respondents with more than 15 years of experience (14.3%) are likely to be senior professionals with significant expertise and influence in the industry.

Table 1: Demographic Characteristics of the Sampled Population.

Demographic Variable	Frequency (n=210)	Percentage (%)
Profession		
Architect	120	57.1
Engineer	90	42.9
Location		
Lagos	50	23.8
Abuja	40	19.0
Kano	30	14.3
Calabar	20	9.5
Port-Harcourt	20	9.5
Aba	15	7.1
Onitsha	15	7.1
Makurdi	10	4.8
Ogun	10	4.8
Years of Experience		
1-5 years	60	28.6
6-10 years	80	38.1
11-15 years	40	19.0
Above 15 years	30	14.3

Table 2: Awareness and adoption of sustainable design strategies.

Sustainable Design Strategy	Awareness (%)	Adoption (%)
Natural Ventilation	90.5	80.5
Solar Control	85.7	75.2
Rainwater Harvesting	76.2	65.7
Local Materials	81.0	70.5

Objective 1: Assess the Awareness and Adoption of Sustainable Design Strategies among Nigerian Architects and Engineers

The first objective sought to examine the level of awareness and adoption of major sustainable architectural design strategies among architects and engineers involved in building projects across Nigeria.

The results from Table 2 show that natural ventilation has the highest awareness rate (90.5%), followed by solar control (85.7%), local materials (81.0%), and rainwater harvesting (76.2%). This suggests that the respondents are more familiar with natural ventilation and solar control strategies, which are commonly used in Nigerian architecture. However, there is a notable gap between awareness and adoption rates for all strategies, indicating that awareness does not necessarily translate to adoption.

The adoption rates are lower than awareness rates for all strategies, with natural ventilation having the highest adoption rate (80.5%), followed by solar control (75.2%), local materials (70.5%), and rainwater harvesting (65.7%). This suggests that while the respondents are aware of these sustainable design strategies, there are barriers to their adoption, such as cost, lack of expertise, or regulatory issues (Unegbu, 2025). The results highlight the need for targeted interventions to increase the adoption of sustainable design strategies in Nigerian architecture, particularly for rainwater harvesting, which has the lowest adoption rate.

Objective 2: Identify Climate-Responsive Design Strategies Suitable for Nigeria's Tropical Climate

The second objective sought to identify climate-responsive architectural strategies considered most suitable for enhancing sustainable building performance in Nigeria's tropical climate. The findings were derived from the thematic analysis of the semi-structured interviews conducted with architects, engineers, and other stakeholders involved in sustainable building projects. Five major themes emerged from the interviews.

Theme One: Natural Ventilation as the Foundation of Sustainable Design

The overwhelming majority of participants identified natural ventilation as the most effective climate-responsive strategy for buildings in Nigeria. Respondents explained that designing buildings to maximize cross-ventilation significantly improves indoor thermal comfort while reducing dependence on mechanical cooling systems.

Many participants emphasized that natural ventilation should be incorporated during the early stages of architectural planning through proper building orientation, strategic placement of windows, open floor layouts, internal courtyards, and adequate spacing between buildings.

One architect commented: *"Natural ventilation remains the simplest and most affordable solution for buildings in Nigeria because it responds directly to our climatic conditions without increasing operational costs."* Another participant noted: *"Architects should prioritize airflow before considering air-conditioning because passive cooling is more sustainable in the long term."*

Participants generally agreed that passive ventilation not only reduces electricity consumption but also improves indoor air quality and enhances occupants' health and comfort.

Theme Two: Solar Control and Building Orientation

Another dominant theme concerned the importance of solar control in minimizing excessive heat gain within buildings. Participants emphasized that building orientation should be determined by prevailing climatic conditions rather than solely by plot configuration or aesthetic considerations.

Respondents recommended incorporating roof overhangs, external shading devices, sun breakers, reflective roofing materials, recessed windows, and vegetation to reduce direct solar radiation.

One respondent observed: *"Many buildings consume excessive electricity simply because they were poorly oriented during the design stage."* Another architect stated: *"Proper orientation reduces indoor temperature naturally and improves overall building performance."*

Participants further explained that combining effective solar control with natural ventilation significantly improves energy efficiency in tropical buildings.

Theme Three: Sustainable Water Management Through Rainwater Harvesting

Interview participants acknowledged the growing importance of rainwater harvesting as a sustainable strategy for addressing water scarcity and improving environmental management. Respondents indicated that harvested rainwater could effectively support domestic activities, landscape irrigation, and sanitation services. However, despite recognizing its benefits, participants noted that rainwater harvesting remains underutilized in most Nigerian building projects. According to one participant,*"Developers understand the benefits of rainwater harvesting, but they often consider it an additional expense that can be omitted."*

Another respondent remarked,

"Without clear government regulations, very few clients demand rainwater harvesting systems during construction."

Participants identified high installation costs, limited client awareness, inadequate maintenance knowledge, and weak policy enforcement as the principal barriers limiting widespread implementation.

Theme Four: Increased Utilization of Indigenous and Sustainable Building Materials

The interviews revealed widespread support for greater utilization of locally available construction materials in sustainable architectural design. Respondents argued that indigenous materials such as compressed earth blocks, stabilized laterite, bamboo, timber, and locally produced reducing transportation costs and environmental impacts.

One participant remarked, *"Traditional building materials have always been compatible with our climate, but modern construction has gradually shifted attention toward imported alternatives."*

Another respondent added, *"Local materials are not only environmentally friendly but also improve affordability and support local industries."*

Participants emphasized that incorporating indigenous materials into contemporary architecture would promote environmental sustainability while preserving Nigeria's architectural heritage.

Theme Five: Landscape Planning and Green Infrastructure

Participants also emphasized the importance of integrating landscape planning into sustainable architectural design. They observed that vegetation, tree planting, green roofs, permeable pavements, and open green spaces contribute significantly to reducing ambient temperatures and mitigating the urban heat island effect. Respondents explained that landscape elements improve stormwater management, enhance biodiversity, and create healthier outdoor environments.

One engineer observed, *"Landscape should not be treated as decoration after construction; it should form part of the architectural design process from the beginning."* Participants generally agreed that sustainable architecture should integrate landscape planning with building design to maximize environmental performance.

Overall, the thematic analysis demonstrates that climate-responsive architectural design in Nigeria depends primarily on the integration of passive cooling strategies, efficient solar control, sustainable water management, the use of indigenous building materials, and environmentally sensitive landscape planning. Participants consistently emphasized that these strategies should be adapted to local climatic conditions, available resources, and socio-economic realities to achieve sustainable building performance.

Objective Three: Propose Guidelines for Integrating Sustainable Design Principles into Nigerian Architectural Education and Professional Practice

The third objective sought to identify practical measures that could enhance the integration of sustainable design principles into architectural education and professional practice in Nigeria. Thematic analysis of the interview data produced six major themes.

Theme One: Review of Architectural Education Curriculum

Participants agreed that sustainability should become a core component of architectural education at undergraduate and postgraduate levels. Respondents observed that although sustainability concepts are introduced in many institutions, they are often treated as supplementary rather than fundamental components of architectural training. Participants recommended that architectural curricula should include climate-responsive design, building energy efficiency, green building assessment systems, renewable energy integration, environmental simulation software, and sustainable construction technologies. One academic participant explained, *"Students should graduate with practical competence in sustainable design rather than simply theoretical knowledge."*

Theme Two: Continuous Professional Development

Respondents emphasized the importance of regular professional development programmes for practicing architects and engineers. Participants recommended workshops, certification programmes, technical seminars, and continuing professional education focusing specifically on sustainable architectural practice. According to one participant, *"Many professionals completed their education before sustainability became a major concern. Continuous training is therefore essential."* Respondents believed that professional development would improve architects' technical competence while increasing confidence in implementing innovative

Table 3: Relationship Between Years of Experience and Adoption of Sustainable Design Strategies.

Sustainable Design Strategy	Correlation Coefficient (r)	p-value
Natural Ventilation	0.45	0.001
Solar Control	0.38	0.005
Rainwater Harvesting	0.32	0.01
Local Materials	0.40	0.002

sustainable technologies.

Theme Three: Strengthening Government Policies and Building Regulations

Participants consistently emphasized the need for stronger government commitment to sustainable architecture through legislation and effective enforcement. Respondents recommended mandatory green building standards, revision of existing building regulations, environmental performance requirements, and incentives for developers adopting sustainable construction practices. One respondent remarked, *"Without supportive government policies, sustainable architecture will continue to depend largely on individual interest."*

Theme Four: Financial Incentives for Sustainable Buildings

Participants highlighted economic constraints as one of the greatest obstacles to sustainable construction. Consequently, they recommended government-supported financial incentives, including tax reductions, grants, subsidized loans, and rebates for environmentally sustainable building projects. Several respondents argued that financial support would encourage private developers to invest in sustainable technologies and innovative construction materials.

Theme Five: Multidisciplinary Collaboration

Participants emphasized that sustainable architecture requires close collaboration among architects, engineers, planners, environmental scientists, quantity surveyors, and policymakers. Respondents explained that integrated project delivery encourages better environmental decision-making throughout the design and construction process. One participant noted, *"No single profession can achieve sustainability independently because every discipline contributes differently to building performance."*

Theme Six: Public Awareness and Client Education

The interviews revealed that many clients remain unaware of the long-term economic and environmental benefits of sustainable buildings. Participants therefore recommended nationwide awareness campaigns, demonstration projects, professional outreach programmes, and public education initiatives. Respondents believed that increasing public demand for sustainable buildings would encourage architects and developers to incorporate climate-responsive strategies more consistently. The findings indicate that integrating sustainable architectural design into Nigerian practice requires coordinated interventions across education, professional training, government policy, financial support, interdisciplinary collaboration, and public awareness. Participants viewed these measures as complementary rather than independent strategies, emphasizing that successful implementation depends on collaboration among educational institutions, professional bodies, policymakers, industry practitioners, and the wider public.

Inferential Analysis

To determine the factors influencing the adoption of sustainable architectural design strategies in Nigeria, Pearson Product Moment Correlation and Multiple Linear Regression analyses were conducted. The correlation analysis examined the relationship between years of professional experience and the adoption of sustainable design strategies, while the regression analysis assessed the combined influence of awareness, years of professional experience, and geographical location on the adoption of sustainable architectural practices.

Relationship Between Years of Professional Experience and the Adoption of Sustainable Design Strategies

Table 3 presents the correlation between years of experience and the adoption of sustainable design strategies among architects and engineers in Nigeria. The results show a significant positive correlation between years of experience and the adoption of all four sustainable design strategies, including natural ventilation ($r = 0.45$, $p = 0.001$), solar control ($r = 0.38$, $p = 0.005$), rainwater harvesting ($r = 0.32$, $p = 0.01$), and local materials ($r = 0.40$, $p = 0.002$). This suggests that as the years of experience increase, the adoption of these sustainable design strategies also increases. The strongest correlation is observed for natural ventilation, indicating that more experienced professionals are more likely to adopt this strategy.

The p-values indicate that the correlations are statistically significant, with all p-values being less than 0.05. This means that the observed correlations are unlikely to be due to chance, and there is strong evidence to suggest that years of experience is a significant predictor of sustainable design strategy adoption. The results imply that more experienced architects and engineers are more likely to adopt sustainable design strategies, possibly due to their increased knowledge, skills, and confidence in implementing these strategies. This highlights the importance of experience and training in promoting the adoption of sustainable design practices in Nigeria.

The results indicate a significant positive correlation between years of experience and adoption of sustainable design strategies ($p < 0.05$).

Factors Influencing the Adoption of Sustainable Design Strategies

A regression analysis was conducted to examine the factors influencing the adoption of sustainable design strategies.

Table 4: Factors Influencing the Adoption of Sustainable Design Strategies.

Independent Variable	Coefficient (β)	p-value
Awareness	0.50	0.001
Years of Experience	0.30	0.005
Location	0.20	0.01

Table 4 presents the results of a regression analysis examining the factors influencing the adoption of sustainable design strategies among architects and engineers in Nigeria. The independent variables include awareness, years of experience, and location. The results show that awareness has the strongest positive effect on the adoption of sustainable design strategies ($\beta = 0.50$, $p = 0.001$), indicating that respondents with higher awareness of sustainable design strategies are more likely to adopt them. This suggests that increasing awareness and knowledge of sustainable design practices is crucial for promoting their adoption in Nigeria.

The results also show that years of experience ($\beta = 0.30$, $p = 0.005$) and location ($\beta = 0.20$, $p = 0.01$) have significant positive effects on the adoption of sustainable design strategies. This means that more experienced professionals and those located in certain regions are more likely to adopt sustainable design strategies. The p-values indicate that these relationships are statistically significant, suggesting that these factors are important predictors of sustainable design strategy adoption. Overall, the results highlight the importance of awareness, experience, and location in promoting the adoption of sustainable design practices in Nigeria.

The results indicate that awareness, years of experience, and location are significant predictors of sustainable design strategy adoption ($p < 0.05$).

DISCUSSION OF FINDINGS

Sustainable Design Practices among Nigerian Architects

The findings revealed that awareness of sustainable architectural design strategies among Nigerian architects and engineers is generally high. Natural ventilation recorded the highest level of awareness, followed by solar control, the use of local building materials, and rainwater harvesting. Despite these encouraging awareness levels, the adoption of these strategies remained comparatively lower, indicating that awareness does not necessarily translate into implementation. The prominence of natural ventilation reflects its compatibility with Nigeria's tropical climatic conditions. Passive cooling through cross-ventilation has long been recognized as one of the most effective methods of improving thermal comfort while minimizing dependence on mechanical air-conditioning systems. This finding agrees with Akinwumi (2019), who argued that natural ventilation remains one of the most appropriate climate-responsive strategies for tropical buildings because it reduces operational energy consumption while improving indoor environmental quality. Similarly, Chen Austin et al. (2024) observed that passive environmental strategies provide substantial energy savings and improve building performance without increasing operational costs.

The relatively high adoption of solar control also demonstrates increasing recognition among Nigerian architects of the importance of reducing solar heat gain. Appropriate building orientation, external shading devices, reflective roofing materials, and optimized window placement reduce indoor temperatures and improve energy efficiency. These findings corroborate those of Cassaignau and Jung (2025), who reported that effective solar control significantly improves thermal comfort and reduces building energy demand in tropical climates. The findings further showed that the use of locally sourced construction materials has gained considerable attention among professionals. This result supports the work of Onyia (2023) and Adetoro and Gambo (2025), who reported that indigenous materials such as compressed earth blocks, laterite, bamboo, and sustainably harvested timber possess favourable thermal characteristics while reducing embodied energy and construction costs. Likewise, Pan et al. (2024) argued that vernacular architectural knowledge remains highly relevant because it demonstrates how locally available materials and passive environmental strategies can be successfully adapted to tropical climatic conditions.

However, although awareness was generally high, adoption remained noticeably lower for all the sustainable design strategies examined. The observed implementation gap suggests that knowledge alone is insufficient to promote widespread sustainable architectural practice. This finding supports Ogunbiyi (2022), who identified high initial investment costs, inadequate technical expertise, limited institutional support, and weak enforcement of environmental regulations as major barriers to sustainable building implementation in Nigeria. Similarly, Toriola-Coker et al. (2021) concluded that inadequate policy incentives and insufficient financing continue to discourage developers from investing in sustainable construction technologies despite growing professional awareness.

The findings strongly support Ecological Modernization Theory, which argues that sustainable development depends on integrating technological innovation with supportive institutional structures and environmental policies. Although Nigerian architects appear increasingly aware of sustainable technologies, the lower adoption rates indicate that the institutional environment has not sufficiently supported their widespread implementation. Sustainable architectural innovation therefore requires not only technical knowledge but also enabling policies, financial incentives, and effective regulatory mechanisms. The findings also reinforce Social Practice Theory, which emphasizes that professional behaviour is shaped by social norms, institutional arrangements, professional competencies, and available resources. The discrepancy between awareness and implementation suggests that sustainable design decisions are influenced by broader organizational and economic realities rather than individual knowledge alone. Architects often operate within constraints imposed by clients, project budgets, market expectations, and existing construction practices, all of which affect their ability to implement sustainable design

strategies.

Climate-Responsive Design Strategies for Nigeria's Tropical Climate

The qualitative findings identified passive cooling through natural ventilation, solar control, rainwater harvesting, the use of indigenous building materials, and integrated landscape planning as the most suitable climate-responsive strategies for sustainable architectural design in Nigeria. Participants consistently emphasized that sustainable architecture should respond directly to Nigeria's climatic conditions rather than relying on imported design concepts developed for temperate environments. The strong preference for passive cooling confirms the continued relevance of traditional environmental design principles within contemporary Nigerian architecture. Participants recognized that maximizing natural ventilation through appropriate building orientation, cross-ventilation, internal courtyards, and strategically positioned openings significantly reduces energy demand while improving occupant comfort. This finding supports Babalola et al. (2024), who reported that passive cooling remains one of the most cost-effective sustainable design strategies for tropical regions.

Participants also emphasized that effective solar control should complement natural ventilation. Proper building orientation, external shading devices, roof overhangs, vegetation, and reflective roofing materials were identified as practical strategies for reducing excessive heat gain. These findings agree with Cassaignau and Jung (2025), who demonstrated that combining passive ventilation with effective solar control substantially improves building energy performance in warm climates. Although respondents acknowledged the environmental benefits of rainwater harvesting, they also identified several barriers limiting its implementation, including high installation costs, limited client demand, inadequate maintenance knowledge, and weak policy enforcement. This finding explains why rainwater harvesting recorded the lowest adoption level in the quantitative analysis despite relatively high awareness. The result aligns with Ogunbiyi (2022), who argued that economic and institutional barriers continue to impede the implementation of sustainable water management systems in Nigeria.

The interviews further highlighted increasing appreciation for locally available construction materials. Participants emphasized that indigenous materials not only possess desirable thermal properties but also reduce transportation costs, minimize environmental impacts, and promote local economic development. This finding corroborates the observations of Pan et al. (2024), Onyia (2023), and Adetoro and Gambo (2025), who advocated greater integration of vernacular construction knowledge into contemporary sustainable architectural practice.

Another important finding concerns landscape planning. Respondents emphasized that trees, green spaces, permeable surfaces, and vegetative shading should be integrated into building design rather than considered as post-construction additions. This integrated approach enhances biodiversity, improves microclimatic conditions, and contributes to climate resilience. These findings further validate Ecological Modernization Theory, which advocates the efficient utilization of environmental resources through technological innovation and ecological planning. Simultaneously, they support Social Practice Theory, as participants consistently emphasized that climate-responsive design decisions are influenced by professional experience, cultural values, client expectations, and institutional practices.

Factors Influencing the Adoption of Sustainable Architectural Design

The correlation analysis demonstrated that years of professional experience are positively associated with the adoption of sustainable architectural design strategies. Natural ventilation exhibited the strongest relationship with professional experience, followed by the use of local materials, solar control, and rainwater harvesting. This finding suggests that architects and engineers accumulate technical competence, environmental knowledge, and practical confidence through continuous professional practice. Experienced professionals are therefore more capable of integrating sustainable strategies into complex building projects. This observation agrees with Babalola et al. (2024), who found that professional exposure significantly improves architects' ability to implement sustainable building technologies.

The regression analysis further revealed that awareness is the strongest predictor of sustainable design adoption, followed by years of professional experience and geographical location. The significance of awareness confirms that knowledge remains an essential prerequisite for sustainable architectural practice. However, awareness alone explains only part of the variation in adoption, indicating that additional contextual factors influence implementation. The significance of geographical location suggests that regional differences in climate, infrastructure, market demand, institutional capacity, and access to sustainable technologies affect architectural practice across Nigeria. Professionals practicing in highly urbanized cities such as Lagos and Abuja may experience greater exposure to sustainable building technologies and professional training than those in less urbanized regions.

These findings reinforce the argument by Diugwu et al. (2021) that contextual factors play a decisive role in determining sustainable architectural practice within Nigeria. They also support Toriola-Coker et al. (2021), who emphasized that institutional capacity, policy implementation, and socio-economic conditions significantly influence the adoption of sustainable construction practices. From the perspective of Ecological Modernization Theory, the regression findings indicate that technological awareness must be accompanied by supportive institutional environments before sustainable innovations can become mainstream. Likewise, Social Practice Theory explains that professional behaviour develops through accumulated experience, organizational learning, and continuous interaction within professional communities. Consequently, improving sustainable architectural practice requires interventions that simultaneously strengthen professional competence, institutional capacity, regulatory support, and public awareness.

Implications of the Findings

The findings have important implications for sustainable architectural practice and policy in Nigeria. Although architects demonstrate substantial awareness of sustainable design principles, implementation remains constrained by financial, institutional, and educational barriers. This suggests that achieving sustainable architecture requires coordinated efforts Among government agencies, professional bodies,

educational institutions, developers, and construction professionals.

The findings further indicate that strengthening architectural education, expanding continuing professional development programmes, revising national building regulations, providing financial incentives for green buildings, and increasing public awareness would substantially improve the adoption of climate-responsive architectural practices. Such interventions would not only improve building performance but also contribute to energy conservation, climate change mitigation, and sustainable urban development within Nigeria.

CONCLUSION

This study provides empirical insights into sustainable design practices in Nigeria's architectural sector, highlighting the gap between awareness and adoption of sustainable design strategies (Umana et al., 2024). The findings underscore the importance of experience, awareness, and location in shaping adoption decisions. To accelerate sustainable design practices in Nigeria, policymakers, educators, and practitioners must address the identified barriers and leverage the influencing factors.

Recommendations

1. To address these challenges, there is a need to enhance awareness and training through workshops and programs focusing on rainwater harvesting and local materials. Policies and incentives should be developed to address cost and expertise barriers. Experienced professionals should mentor younger architects and engineers, and location-specific guidelines incorporating vernacular architecture principles should be created.
2. To bridge the awareness-adoption gap, Nigerian policymakers and professional bodies should prioritize capacity building by providing training, workshops, and resources to enhance architects' and engineers' skills in sustainable design. Also, incentivization by offering financial incentives, tax breaks, or recognition programs to encourage adoption of sustainable design strategies.
3. Furthermore, development control agencies should offer policy support by developing and enforcing building codes, regulations, and standards that promote sustainable design practices. There is also a need for knowledge sharing to facilitate knowledge exchange platforms for professionals to share experiences and best practices. By addressing these areas, Nigeria can accelerate the adoption of sustainable design strategies, contributing to a more environmentally responsive and resilient built environment.

Limitations

This study has several limitations. Firstly, the sample focused on architects and engineers in Nigeria, potentially limiting generalizability to other stakeholders or contexts. Secondly, the study relied on self-reported data, which may be subject to bias. Future research should consider objective measures of sustainable design adoption and explore other stakeholders' perspectives. Also, further research on the scalability and replicability of sustainable projects in different Nigerian contexts is necessary.

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