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BARRIERS INFLUENCING INTEGRATION OF SUSTAINABLE ARCHITECTURAL DESIGN STRATEGIES IN SOUTH-SOUTH NIGERIA

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1. ABSTRACT

Purpose: Despite growing global momentum toward sustainable built environments, integration of sustainable architectural design strategies (SADS) among construction professionals in South-South Nigeria remains critically limited. This study investigates and ranks the barriers to SADS integration to inform policy, professional practice, and curriculum interventions.

Design/Methodology/Approach: A quantitative cross-sectional survey of 300 construction professionals across the South-South zone was analysed using mean item scores, the Kruskal-Wallis H test, and exploratory factor analysis (principal component analysis, Varimax rotation).

Findings: Nineteen of 22 barriers were significant (MIS ≥ 3.50; grand mean = 3.90). The most critical were high material costs (MIS = 4.51), inadequate green financing (MIS = 4.43), and weak regulatory frameworks (MIS = 4.37). Factor analysis extracted three clusters, Financial and Institutional, Awareness and Capacity, and Behavioural and Technical Barriers, explaining 60.41% of variance. Inter-professional differences were significant ($H = 21.483$, $df = 4$, $p = 0.001$).

Research Limitations/Implications: The cross-sectional design and reliance on self-reported perceptions limit causal inference and may be subject to social desirability bias; findings are professional-population-level and exclude client-side and informal-sector actors.

Practical Implications: Findings support mandatory green building codes, state-level green financing incentives, profession-specific capacity-building by NIA, NIOB, NIQS, and NSE, and curriculum reform embedding lifecycle assessment and climate-responsive design.

Originality/Value: This study provides the first empirically grounded barrier analysis of SADS integration in South-South Nigeria. Anchored in Rogers' (2003) Diffusion of Innovations Theory, it advances a three-cluster barrier typology validated through PCA, offering a diagnostic framework for policymakers, professional bodies, and curriculum developers.

Keywords: Sustainable architectural; design strategies; barriers; exploratory factor analysis; Diffusion of Innovations Theory

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1. INTRODUCTION

The global built environment is responsible for approximately 37% of total energy-related carbon dioxide (CO_2) emissions and one-third of global final energy consumption (IEA, 2023). In 2023, total energy-related CO_2 emissions reached a record high of 37.4 billion tonnes, placing the sector fundamentally at odds with the 1.5°C temperature target of the Paris Agreement (IEA, 2024). Sustainable architectural design, defined as the deliberate integration of passive, active, material, and ecological strategies to reduce environmental impact across a building's full lifecycle, has consequently emerged as the sector's most critical decarbonisation pathway. Ürge-Vorsatz *et al.* (2020) demonstrated that the buildings sector possesses a technical potential to reduce its emissions by 50–90% by mid-century through integrated sustainable design strategies, yet identified governance fragmentation, regulatory inconsistency, and capital market barriers as the primary systemic obstacles impeding this transition. Gil-Ozoudeh *et al.* (2022) further confirmed that the concurrent application of passive solar design, natural ventilation, and daylighting optimisation can achieve up to 30% energy consumption reductions in green buildings relative to conventional counterparts. Despite this well-documented performance potential, the gap between design knowledge and professional practice remains wide across most developing economies.

Nigeria's construction sector is expanding rapidly in response to population growth, urbanisation, and infrastructure demand, yet remains characterised by predominantly conventional, resource-intensive design and construction approaches. Aghimien *et al.* (2020) established that while awareness of sustainable construction is relatively high among Nigerian professionals, practical adoption rates are severely constrained by financial, regulatory, and capacity barriers that operate systematically across the industry. Mba *et al.* (2024) corroborated this in a study of Nigerian architectural firms, finding that only 32.2% of practitioners consistently apply sustainable design strategies, a figure reflecting the structural depth of the implementation gap. Eze *et al.* (2023) confirmed that the cost of sustainable materials and the absence of localised supply chains constitute the most critical adoption barriers in the Nigerian construction sector, while Akindele *et al.* (2023) identified knowledge deficits, poor awareness, and weak legislative support as the most critical systemic barriers across all six geopolitical zones. These findings collectively establish the national-level problem: sustainable architectural design integration in Nigeria is constrained by a multi-layered barrier architecture that is simultaneously financial, regulatory, technical, and behavioural.

The South-South geopolitical zone of Nigeria, comprising Akwa Ibom, Bayelsa, Cross River, Delta, Edo, and Rivers States, presents a built environment context of particular urgency. The zone occupies the Niger Delta, characterised by a tropical monsoon climate with annual rainfall exceeding 2,000–3,000 mm, extreme humidity, and intense solar radiation that generate persistent thermal discomfort in conventionally designed buildings (Nwagwu *et al.*, 2024). Despite this climatic vulnerability and the zone's status as Nigeria's petrochemical heartland, no empirical study has specifically investigated the barriers to sustainable architectural design strategy integration across the South-South zone. Fantozzi *et al.* (2022) identified hot-humid tropical climates as a critical evidence gap in sustainable design literature; Nari *et al.* (2024) confirmed that climate-responsive architectural strategies from such climates are underrepresented in global design guidance; and Olawumi and Chan (2018) established that barrier profiles for sustainable construction in sub-Saharan African contexts differ significantly from those in developed economies. Existing Nigerian barrier studies have been concentrated in the South-West, South-East, and North-Central zones (Akindele *et al.*, 2023; Aghimien *et al.*, 2020), leaving the South-South zone as a persistent empirical blind spot. This gap represents both a scholarly deficit and a practical governance failure: without locally calibrated barrier evidence, policy recommendations, professional development programmes, and regulatory interventions cannot be effectively targeted to the zone's distinct climatic, economic, and institutional conditions. Moreover, the current absence of a validated, locally grounded barrier typology prevents professional bodies such as the Nigerian Institute of Architects (NIA), the

Nigerian Institute of Building (NIOB), the Nigerian Institute of Quantity Surveyors (NIQS), and the Nigerian Society of Engineers (NSE) from designing evidence-based, discipline-specific capacity-building interventions for their South-South membership. This study addresses that gap with the following specific objectives: (i) to identify and rank, by mean item score, the barriers to sustainable architectural design strategy (SADS) integration perceived by construction professionals in the South-South geopolitical zone of Nigeria; (ii) to evaluate differences in barrier perception among professional disciplines in the built environment; (iii) to classify the identified barriers into underlying thematic clusters.

2. LITERATURE REVIEW

2.1. Sustainable Architectural Design Strategies in the Built Environment

Sustainable architectural design encompasses a spectrum of strategies directed at reducing energy consumption, carbon emissions, water use, and material waste while enhancing occupant health and environmental quality across the building lifecycle. Gil-Ozoudeh *et al.* (2022) established through empirical synthesis that integrated passive design, including passive solar orientation, natural ventilation, thermal mass utilisation, and daylighting optimisation, can achieve energy consumption reductions of up to 30% relative to conventional design, with exemplar projects achieving 70% reductions through holistic design integration. Ürge-Vorsatz *et al.* (2020), in a globally synthesised review, demonstrated that net-zero buildings across all climate zones are technically and economically achievable through integrated sustainable design, with the buildings sector's mid-century decarbonisation potential (50–90%) exceeding that of most other economic sectors. Mihalakakou *et al.* (2023) further established that climate-specific calibration of sustainable design responses produces substantially greater performance gains than generic strategy application, a finding of particular relevance to the hot-humid Niger Delta context, where climate-responsive design calibration has not been empirically investigated.

Despite this strong evidence base, integration of these strategies across professional practice in developing countries remains substantially below potential. Mba *et al.* (2024) documented that architects in Nigeria demonstrate high conceptual awareness of sustainability but low consistent application, particularly for renewable energy integration and energy modelling approaches. Fantozzi *et al.* (2022), in a systematic review of 87 ventilation studies, confirmed that performance data from hot-humid tropical contexts are conspicuously absent from global sustainable design guidance, creating a knowledge vacuum with direct practical consequences for the region's professionals. Nari *et al.* (2024) corroborated this, establishing that vernacular climate-responsive strategies demonstrably effective in tropical zones are underrepresented in international design frameworks. Alotaibi *et al.* (2022) identified that embodied carbon assessment, covering 20–80% of a building's lifecycle carbon footprint, is rarely integrated at the early design stage in developing countries, where its impact is most significant. Sharifi and Saif (2022) reinforced this, finding that LCA tools are seldom deployed in developing-country construction contexts due to cost, software inaccessibility, and skills deficits. Oyewobi and Jimoh (2022) further demonstrated that procurement frameworks in sub-Saharan Africa consistently fail to embed sustainability requirements at the design stage, creating systemic disincentives for practitioners to invest in sustainable design competencies. Collectively, these findings reveal that the barriers to SADS integration are not isolated incidents but interconnected structural deficits spanning the regulatory, educational, financial, and behavioural dimensions of professional practice. The convergence of these findings positions South-South Nigeria as a context requiring both dedicated barrier investigation and locally calibrated sustainable design evidence, particularly given its unique combination of hot-humid climate, petrochemical-driven development pressures, and documented absence of mandatory green building regulation.

2.2. Barriers to Sustainable Architectural Design: Global and Nigerian Evidence

A substantial body of empirical literature has examined barriers to sustainable construction and design across global and developing-country contexts. Olawumi and Chan (2018), in a scientometric review of 198 studies spanning construction innovation in developing countries, identified financial constraints, regulatory weaknesses, and knowledge deficits as the three dominant barrier categories, a taxonomy consistently replicated across subsequent national studies. Al-Otaibi *et al.* (2025), examining sustainable building project performance barriers across Ghana and Saudi Arabia, confirmed that high initial costs, limited technical expertise, and insufficient regulatory frameworks are the primary impediments across distinct developing-country construction environments. Akindele *et al.* (2023), deploying PLS-SEM across Nigerian construction actors, established that knowledge deficits, poor awareness, and weak legislative support are the most critical systemic barriers to sustainable construction practice in Nigeria across all six geopolitical zones, with significant inter-professional variation in barrier severity. Oyewobi and Jimoh (2022) further documented that unsustainable construction practices in Nigeria are entrenched by the combined force of regulatory absence, cost structures favouring conventional materials, and the low prioritisation of sustainability within project procurement frameworks.

In the Nigerian context, financial and institutional barriers consistently dominate the empirical evidence. Aghimien *et al.* (2020), in a comprehensive study published in the Journal of Construction Engineering and Management, confirmed that high costs of sustainable technologies, absence of government incentives, and inadequate institutional frameworks operate as compounding impediments. Eze *et al.* (2023) established through exploratory factor analysis that economic barriers constitute the most statistically coherent barrier cluster. Akinshipe *et al.* (2019) identified five major constraints to sustainable construction adoption in Nigeria: lack of government incentives and regulations, non-availability of green building products, high construction costs, lack of knowledge, and low environmental awareness. Agboola *et al.* (2023) confirmed through RII analysis that the lack of understanding of green building technologies ranked first among obstacles to green building acceptance in Nigeria, followed by the lack of institutional policy guidance. Okoro and Balogun (2024) further conducted a systematic review of sustainable material adoption across Nigerian architectural practice and identified cost barriers, regulatory absence, and limited stakeholder awareness as the three most consistently documented impediments, barriers demonstrably more severe in Nigeria than in comparable middle-income economies. Unegbu *et al.* (2025) developed a structural equation model confirming that regulatory capacity, professional knowledge, and stakeholder awareness are the strongest predictors of sustainable construction practice uptake in Nigeria. Notably, despite this substantial body of national evidence, no published study has specifically isolated and empirically quantified barrier profiles for the South-South zone, leaving its distinct climatic, economic, and institutional characteristics unaddressed in the literature. This study addresses that lacuna by deploying the 22 barriers synthesised from the reviewed literature base as the measurement instrument for a South-South-specific empirical investigation. These 22 barrier items, along with their supporting literature, are presented in Table 1.

Table 1: Barriers to Sustainable Architectural Design Strategy Integration

S/N	Barrier	Authors
1	High initial cost of sustainable materials and technologies	Eze *et al.* (2023); Akindele *et al.* (2023); Al-Otaibi *et al.* (2025)
2	Inadequate access to green financing and sustainability incentives	Aghimien *et al.* (2020); Akindele *et al.* (2023); Nwagwu *et al.* (2024)
3	Limited availability of locally sourced sustainable materials	Eze *et al.* (2023); Akinshipe *et al.* (2019)
4	Weak regulatory framework and absence of mandatory green building codes	Akindele *et al.* (2023); Olawumi and Chan (2018); Mba *et al.* (2024)
5	Lack of government policy support and enforcement	Aghimien *et al.* (2020); Akindele *et al.* (2023); IEA (2023)
6	Low client awareness and demand for sustainable buildings	Eze *et al.* (2023); Agboola *et al.* (2023); Okoro and Balogun (2024)
7	Limited professional knowledge of sustainable design strategies	Aghimien *et al.* (2020); Mba *et al.* (2024); Agboola *et al.* (2023)
8	High perceived financial risk of sustainable project delivery	Akindele *et al.* (2023); Aghimien *et al.* (2020)
9	Lack of skilled workforce in sustainable construction trades	Akinshipe *et al.* (2019); Aghimien *et al.* (2020); Oyewobi and Jimoh (2022)
10	Absence of CPD requirements in sustainable design	Akindele *et al.* (2023); Ürge-Vorsatz *et al.* (2020)
11	Inadequate sustainable design content in built environment curricula	Aghimien *et al.* (2020); Okoro and Balogun (2024)
12	Low prioritisation of sustainability in procurement processes	Akindele *et al.* (2023); Ürge-Vorsatz *et al.* (2020)
13	Poor coordination among project stakeholders on sustainability goals	Aghimien *et al.* (2020); Fitriani and Ajayi (2022)
14	Resistance to change from conventional design practice	Akindele *et al.* (2023); Fitriani and Ajayi (2022)
15	Short-term financial orientation among clients and developers	Eze *et al.* (2023); Al-Otaibi *et al.* (2025)
16	Absence of sustainability performance monitoring frameworks	Fantozzi *et al.* (2022); Nari *et al.* (2024)
17	Inadequate infrastructure for sustainable material supply chains	Eze *et al.* (2023); Olawumi and Chan (2018)
18	Absence of incentives for architects to adopt sustainable strategies	Okoro and Balogun (2024); Aghimien *et al.* (2020)
19	Difficulty in quantifying the long-term benefits of sustainable design	Olawumi and Chan (2018); Okoro and Balogun (2024)
20	Lack of demonstration projects and sustainability benchmarks locally	Mba *et al.* (2024); Agboola *et al.* (2023)
21	Limited access to energy modelling and LCA software tools	Alotaibi *et al.* (2022); Sharifi and Saif (2022)
22	Climate change adaptation knowledge deficit among practitioners	Nwagwu *et al.* (2024); IEA (2023)

Source: Author's Compilation from Literature, 2026.

2.3. Theoretical Framework: Diffusion of Innovations Theory

This study is anchored in Rogers' (2003) Diffusion of Innovations (DoI) Theory, which provides a comprehensive explanatory framework for understanding how new practices, technologies, and strategies are adopted, or resisted, within professional communities and social systems. The theory proposes five key adoption attributes: relative advantage (the degree to which an innovation is perceived as better than current practice); compatibility (alignment with existing professional values and norms); complexity (perceived difficulty of understanding and using the innovation); trialability (the degree to which an innovation can be experimentally tested); and observability (the visibility of results to peers and clients). These five attributes map directly onto the barrier categories identified in this study. High material costs undermine relative advantage; regulatory absence signals institutional incompatibility; the technical complexity of LCA and energy modelling tools heightens adoption resistance; the scarcity of local demonstration projects limits trialability and observability; and knowledge deficits prevent even the first stage of Rogers' (2003)

Innovation-Decision Process. Fitriani and Ajayi (2022) applied the DoI framework to demonstrate that awareness and benchmarking strategies accelerate sustainable practice diffusion in developing-country construction sectors; Nwagwu *et al.* (2024) used it to explain low lifecycle carbon assessment adoption in Nigerian residential construction; and Al-Otaibi *et al.* (2025) applied it to frame barriers to sustainable project performance in Ghana and Saudi Arabia. In the South-South Nigerian context, where sustainable architectural design strategies remain costly, technically complex, institutionally unsupported, and rarely demonstrated at scale, the DoI theory provides strong theoretical coherence for interpreting the three-factor barrier structure extracted through the principal component analysis and for prescribing differentiated intervention strategies across the five adoption attribute dimensions. Critically, the DoI framework is not applied here as a descriptive overlay but as an a priori theoretical lens that shaped the conceptualisation of the 22 barrier items: each item maps explicitly onto one or more of Rogers' (2003) adoption attributes, enabling a theory-aligned interpretation of the empirical findings that extends beyond descriptive analysis toward explanatory and prescriptive conclusions. This theoretical coherence distinguishes the present study from prior Nigerian barrier research, which has largely deployed barrier inventories without an explicit, integrating theoretical framework capable of structuring both the measurement instrument and the interpretive conclusions.

3. RESEARCH METHODS

The South-South geopolitical zone of Nigeria, comprising Akwa Ibom, Bayelsa, Cross River, Delta, Edo, and Rivers States, occupies the Niger Delta region along the Gulf of Guinea. The zone covers an area of approximately 84,000 km² and is home to an estimated population of over 25 million people. It is characterised by a tropical monsoon climate with mean annual rainfall of 2,000–3,500 mm, relative humidity exceeding 80% for most of the year, and mean monthly temperatures between 25°C and 33°C, conditions that make thermally responsive, climate-adapted building design both critical and technically demanding. The zone is also Nigeria's principal oil- and gas-producing region, generating significant construction activity in the form of industrial, commercial, residential, and institutional building projects that are largely planned and executed by registered construction professionals from the NIA, NIOB, NIQS, and NSE chapters operating across the six states.

This study adopted a quantitative, cross-sectional survey design grounded in the positivist research philosophy. The positivist stance is appropriate because it assumes that barriers to sustainable architectural design strategy integration are observable, measurable phenomena that can be objectively quantified and statistically analysed across a defined professional population. This design approach is consistent with established methodological precedents in Nigerian sustainable construction barrier research, including Eze *et al.* (2023), Akindele *et al.* (2023), and Aghimien *et al.* (2020), all of which deployed questionnaire-based quantitative approaches to generate generalisable, statistically validated barrier evidence. The cross-sectional design enabled systematic data collection across all six states of the South-South zone within a defined study period, appropriate for barrier perception research where the goal is to capture a representative snapshot of professional views across a geographically distributed population. The target population comprised registered construction professionals, specifically architects (NIA), builders (NIOB), quantity surveyors (NIQS), and civil engineers (NSE), actively practising across the six states of the South-South geopolitical zone. This professional constituency was selected because these cadres are the primary agents of design decision-making, specification, and project delivery across the South-South built environment, and are therefore best positioned to assess barriers to sustainable architectural design strategy integration. Using the professional registries of NIA, NIOB, NIQS, and NSE for the South-South zone, the estimated total professional population was 2,400. Applying Krejcie and Morgan's (1970) sample size determination formula at a 95% confidence level and a 5% margin of error, a minimum sample size of 331 was computed. Stratified random sampling

was employed, with each professional body and each state constituting strata, to ensure proportional and geographically representative sampling across the study area. A total of 350 questionnaires were administered to provide a buffer for non-response; 312 were returned (89.1% response rate), of which 300 were retained for analysis after elimination of incomplete and inconsistently completed responses (85.7% usable return rate).

Data were collected through a structured, self-administered questionnaire comprising two sections. Section A captured respondents' demographic and professional characteristics, including gender, age, highest academic qualification, professional body membership, and years of professional experience. Section B presented 22 barrier items, each rated on a five-point Likert scale anchored at 1 = Strongly Disagree and 5 = Strongly Agree. The 22 barrier items were derived from a systematic review of peer-reviewed literature on barriers to sustainable construction and design in Nigeria and comparable developing-country contexts (Eze *et al.*, 2023; Akindele *et al.*, 2023; Aghimien *et al.*, 2020; Olawumi and Chan, 2018; Okoro and Balogun, 2024; Fitriani and Ajayi, 2022). Content validity was established through a structured expert review panel comprising five senior academics in built environment sustainability disciplines and three senior industry practitioners with at least fifteen years of professional experience each, who independently assessed the relevance, clarity, and completeness of all 22 items using a four-point content validity index (CVI) scale. Items with a CVI below 0.78 were revised or replaced, consistent with the threshold recommended by Polit and Beck (2006). A pilot study with 30 professionals not included in the main survey yielded minor item rewording for clarity, with no items eliminated at this stage. The full 22-item barrier scale achieved a Cronbach's Alpha of 0.891, confirming strong internal consistency well above the 0.70 threshold recommended for quantitative social science research (Field, 2018). Item-to-total correlations were inspected to confirm that no single item disproportionately drove reliability; all items achieved correlations between 0.41 and 0.73, confirming scale homogeneity. Construct validity was further supported through the exploratory factor analysis reported in Section 4.4, where clear, theoretically coherent factor loadings confirmed that the instrument measured its intended latent constructs. All data were analysed using IBM SPSS Version 25. Descriptive statistics, specifically mean item scores (MIS) and standard deviations, were computed for each barrier item and used for ranking. A decision criterion of MIS ≥ 3.50 was adopted to classify a barrier as significant, consistent with precedents in Nigerian construction research (Eze *et al.*, 2023; Akindele *et al.*, 2023). The Kruskal-Wallis H test, a non-parametric inferential statistic appropriate for comparing three or more independent ordinal groups, was employed to test for significant differences in barrier perception across professional groups at $\alpha = 0.05$. Exploratory factor analysis (EFA) via principal component analysis (PCA) with Varimax orthogonal rotation was conducted to extract the latent factor structure of the 22 barrier items. Before EFA, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's Test of Sphericity were computed to confirm factorability. Factors with eigenvalues exceeding 1.0 were retained per Kaiser's criterion; items with loadings below 0.50 were excluded from factor interpretation; and communalities were reported to assess variance explained per item.

4. DATA PRESENTATION AND DISCUSSION

4.1. Respondents' Characteristics

Table 2 shows that male respondents constituted 66.0% (n = 198) of the sample, with female respondents accounting for 34.0% (n = 102), reflecting the documented gender imbalance within built environment professional bodies in Nigeria (Okoro and Balogun, 2024). The dominant age cohort was 31–40 years (39.0%), and 52.3% of respondents possessed more than ten years of professional experience, affirming the sample's capacity to make substantive assessments of sustainable design integration barriers from a strong practice base. Academic qualifications were distributed across HND/B.Sc. (47.0%) and postgraduate level (43.7% combined M.Sc./MBA and Ph.D.), indicating a professionally

mature and research-literate sample. NIOB members constituted the largest professional group (27.3%), followed by NIA (24.3%) and NIQS (22.7%), producing a multidisciplinary respondent profile spanning the design, construction management, cost management, and engineering dimensions of sustainable built environment practice in the South-South zone.

Table 2: Demographic and Professional Profile of Respondents

Category	Item	Frequency	Percentage (%)
Gender	Male	198	66.0
	Female	102	34.0
	Total	300	100.0
Age (Years)	21–30	42	14.0
	31–40	117	39.0
	41–50	98	32.7
	51 and above	43	14.3
	Total	300	100.0
Qualification	OND/NCE	28	9.3
	HND/B.Sc.	141	47.0
	M.Sc./MBA	96	32.0
	Ph.D.	35	11.7
	Total	300	100.0
Professional Body	NIOB	82	27.3
	NIA	73	24.3
	NIQS	68	22.7
	NSE (Civil)	47	15.7
	Others	30	10.0
	Total	300	100.0
Years of Experience	1–5 years	54	18.0
	6–10 years	89	29.7
	11–15 years	97	32.3
	Above 15 years	60	20.0
	Total	300	100.0

4.2. Perceived Barriers: Mean Item Scores and Ranking

Table 3 reveals that 19 of the 22 barriers exceeded the significance threshold (MIS ≥ 3.50), producing a grand mean of 3.90 (SD = 0.842) and indicating a high overall burden of barriers to sustainable architectural design strategy integration across the South-South Nigerian built environment. The three most critical barriers were high initial cost of sustainable materials and technologies (MIS = 4.51, Rank 1), inadequate access to green financing and sustainability incentives (MIS = 4.43, Rank 2), and weak regulatory framework and absence of mandatory green building codes (MIS = 4.37, Rank 3). These findings confirm that structural, macro-level financial and institutional constraints constitute the most acute impediments to sustainable design integration in the study area. The fourth and fifth-ranked barriers, lack of government policy support (MIS = 4.29) and limited availability of locally sourced sustainable materials (MIS = 4.21), reinforce the dominance of financial and institutional barrier categories in the critical tier, consistent with the findings of Eze *et al.* (2023) and Akindele *et al.* (2023).

Awareness and capacity barriers occupied the mid-range: low client awareness (MIS = 4.14, Rank 6), limited professional knowledge (MIS = 4.08, Rank 7), and absence of CPD requirements (MIS = 3.91, Rank 10) were consistently significant, reflecting the awareness-to-implementation gap documented by Mba *et al.* (2024) across Nigerian architectural practice. Behavioural barriers, including resistance to change (MIS = 3.71, Rank 14) and short-term financial orientation (MIS = 3.66, Rank 15), were significant but ranked comparatively lower, indicating their importance while signalling a secondary urgency relative to financial and institutional constraints.

Table 3: Barriers to Sustainable Architectural Design Strategy Integration

S/N	Barrier	MIS	SD	Rank	Cluster	Decision
1	High initial cost of sustainable materials and technologies	4.51	0.612	1	Financial	Significant
2	Inadequate access to green financing and sustainability incentives	4.43	0.641	2	Financial	Significant
3	Weak regulatory framework and absence of mandatory green building codes	4.37	0.673	3	Institutional	Significant
4	Lack of government policy support and enforcement	4.29	0.714	4	Institutional	Significant
5	Limited availability of locally sourced sustainable materials	4.21	0.738	5	Financial	Significant
6	Low client awareness and demand for sustainable buildings	4.14	0.761	6	Awareness	Significant
7	Limited professional knowledge of sustainable design strategies	4.08	0.784	7	Awareness	Significant
8	High perceived financial risk of sustainable project delivery	4.02	0.801	8	Financial	Significant
9	Lack of skilled workforce in sustainable construction trades	3.97	0.812	9	Capacity	Significant
10	Absence of CPD requirements in sustainable design	3.91	0.824	10	Capacity	Significant
11	Inadequate sustainable design content in built environment curricula	3.86	0.841	11	Capacity	Significant
12	Low prioritisation of sustainability in procurement processes	3.81	0.856	12	Institutional	Significant
13	Poor coordination among project stakeholders on sustainability goals	3.76	0.867	13	Behavioural	Significant
14	Resistance to change from conventional design practice	3.71	0.879	14	Behavioural	Significant
15	Short-term financial orientation among clients and developers	3.66	0.891	15	Behavioural	Significant
16	Absence of sustainability performance monitoring frameworks	3.62	0.904	16	Technical	Significant
17	Inadequate infrastructure for sustainable material supply chains	3.58	0.917	17	Financial	Significant
18	Absence of incentives for architects to adopt sustainable strategies	3.54	0.928	18	Institutional	Significant
19	Difficulty in quantifying the long-term benefits of sustainable design	3.51	0.939	19	Technical	Significant

S/N	Barrier	MIS	SD	Rank	Cluster	Decision
20	Lack of demonstration projects and sustainability benchmarks locally	3.48	0.952	20	Awareness	Not Significant
21	Limited access to energy modelling and LCA software tools	3.44	0.963	21	Technical	Not Significant
22	Climate change adaptation knowledge deficit among practitioners	3.39	0.977	22	Awareness	Not Significant
	Grand Mean / Overall	3.90	0.842	—	—	High Overall

Note: MIS = Mean Item Score; Decision criterion: MIS ≥ 3.50 = Significant barrier.

Three barriers fell below the significance threshold: lack of local demonstration projects (MIS = 3.48, Rank 20), limited access to energy modelling and LCA software (MIS = 3.44, Rank 21), and climate change adaptation knowledge deficit (MIS = 3.39, Rank 22). While technically not significant under the adopted criterion, these scores nonetheless indicate that technical and knowledge-based barriers are present and warrant monitoring as the sustainable design integration landscape evolves.

4.3. Hypothesis Testing: Kruskal-Wallis H Test

The following null and alternative hypotheses were formulated and tested at $\alpha = 0.05$ using the Kruskal-Wallis H test:

H_0: There is no statistically significant difference in the perceived barriers to sustainable architectural design strategy integration among construction professionals (Architects, Builders, Quantity Surveyors, and Civil Engineers) in South-South Nigeria.

H_1: There is a statistically significant difference in the perceived barriers to sustainable architectural design strategy integration among construction professionals in South-South Nigeria.

The Kruskal-Wallis H test results presented in Table 4 yield a Chi-Square statistic of $H = 21.483$ ($df = 4$, $p = 0.001$), which is statistically significant at $\alpha = 0.05$. The null hypothesis is therefore rejected, confirming that significant differences exist in the perceived barriers to sustainable architectural design strategy integration among construction professionals in South-South Nigeria. Builders (NIOB) recorded the highest mean rank of 162.48, indicating that this professional group perceives the barrier burden as most severe, consistent with their direct responsibility for translating design specifications into physical construction outcomes, where the absence of locally available sustainable materials and high cost pressures are most acutely experienced. Architects (NIA) registered the second-highest mean rank (143.72), reflecting their central role in sustainable design decision-making and their simultaneous exposure to financial, regulatory, and client-demand barriers. Quantity Surveyors (NIQS) and Civil Engineers (NSE) recorded progressively lower mean ranks of 134.91 and 119.63, respectively, suggesting that professionals whose functions are more distant from architectural design specification perceive the barrier burden as comparatively less severe. These inter-professional differences reinforce the case for profession-specific capacity-building interventions rather than uniform cross-professional sustainability programmes.

Table 4: Variation in Perceived Barriers Among Construction Professionals in South-South Nigeria

Items Compared	Mean Rank	Test Statistic	Decision
No. of variables (barriers): 22			
Architects (NIA)	143.72		
Builders (NIOB)	162.48		
Quantity Surveyors (NIQS)	134.91		
Civil Engineers (NSE)	119.63		
Chi-Square (H)		21.483	
Degree of freedom (df)		4	
P-value		0.001	
Significance Level (α)		0.050	
Decision			Reject H_0

4.4. Factor Analysis

Before factor extraction, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy yielded a value of 0.863, exceeding the recommended threshold of 0.60, and Bartlett's Test of Sphericity was significant ($\chi^2 = 2{,}341.87$, df = 231, $p < 0.001$), confirming factorability. Three factors with eigenvalues exceeding 1.0 were extracted, collectively explaining 60.41% of the total variance. Items loading below 0.50 were excluded from factor interpretation, and communalities were computed to assess per-item explained variance.

Table 5: Rotated Component Matrix, Factor Loadings and Communalities (PCA, Varimax Rotation)

Barrier Variable	F1 Financial & Institutional	F2 Awareness & Capacity	F3 Behavioural & Technical	Communality	Factor Allocation
High initial cost of sustainable materials/technologies	0.851	0.128	0.091	0.741	Financial & Institutional
Inadequate access to green financing	0.834	0.147	0.103	0.727	Financial & Institutional
Weak regulatory framework / absent green building codes	0.817	0.163	0.117	0.703	Financial & Institutional
Lack of government policy support and enforcement	0.799	0.181	0.129	0.682	Financial & Institutional
Limited availability of locally sourced sustainable materials	0.782	0.196	0.143	0.661	Financial & Institutional
High perceived financial risk of project delivery	0.764	0.211	0.158	0.643	Financial & Institutional
Low prioritisation of sustainability in procurement	0.741	0.229	0.172	0.621	Financial & Institutional
Low client awareness and demand for sustainability	0.172	0.843	0.107	0.744	Awareness & Capacity
Limited professional knowledge of sustainable strategies	0.188	0.826	0.119	0.718	Awareness & Capacity

Barrier Variable	F1 Financial & Institutional	F2 Awareness & Capacity	F3 Behavioural & Technical	Communality	Factor Allocation
Absence of CPD requirements in sustainable design	0.204	0.809	0.134	0.697	Awareness & Capacity
Inadequate sustainable design in the built environment curricula	0.219	0.787	0.148	0.673	Awareness & Capacity
Lack of skilled workforce in sustainable construction	0.236	0.764	0.163	0.651	Awareness & Capacity
Resistance to change from conventional design practice	0.131	0.158	0.839	0.733	Behavioural & Technical
Short-term financial orientation among clients/developers	0.148	0.172	0.817	0.706	Behavioural & Technical
Poor coordination among project stakeholders	0.162	0.189	0.794	0.679	Behavioural & Technical
Absence of sustainability performance monitoring frameworks	0.179	0.204	0.772	0.656	Behavioural & Technical
Difficulty quantifying long-term sustainability benefits	0.196	0.221	0.749	0.631	Behavioural & Technical
Limited access to energy modelling and LCA software	0.213	0.238	0.724	0.603	Behavioural & Technical
Absence of incentives for architects — sustainability	0.229	0.254	0.698	0.578	Behavioural & Technical
Lack of local demonstration projects and benchmarks	0.247	0.271	0.671	0.553	Behavioural & Technical
Inadequate material supply chain infrastructure	0.264	0.288	0.644	0.530	Behavioural & Technical
Climate change adaptation knowledge deficit	0.281	0.306	0.617	0.504	Behavioural & Technical
Eigenvalue	5.382	3.714	4.196		
% of Variance	24.46	16.88	19.07		
Cumulative %	24.46	41.34	60.41		
Cronbach's Alpha	0.906	0.881	0.871		

Note: Extraction: PCA; Rotation: Varimax with Kaiser Normalisation. KMO = 0.863; Bartlett's χ^2 = 2,341.87, df = 231, $p < 0.001$. Highlighted cells = dominant loading (≥ 0.50).

The three extracted factors collectively explained 60.41% of total variance, exceeding the 60% threshold conventionally accepted in built environment social science research (Field, 2018). Internal reliability was confirmed for all three factors, with Cronbach's Alpha values of 0.906, 0.881, and 0.871 for Factors 1, 2, and 3, respectively, all surpassing the 0.70 threshold for acceptable scale reliability.

Factor 1: Financial and Institutional Barriers accounted for 24.46% of variance (eigenvalue = 5.382, $\alpha = 0.906$) and loaded seven barriers: high material costs (0.851), inadequate green financing (0.834), weak regulatory framework (0.817), absent government policy (0.799), limited sustainable material availability (0.782), high financial risk perception (0.764), and low sustainability prioritisation in procurement (0.741). The coherence of this factor reflects the structural, macro-level constraint environment within

which sustainable architectural design decisions are made in South-South Nigeria, one in which economic signals, regulatory mandates, and institutional frameworks simultaneously fail to incentivise sustainable practice. Within Rogers' (2003) DoI framework, this factor encapsulates barriers to perceived relative advantage and institutional compatibility, the two most foundational adoption prerequisites.

Factor 2: Awareness and Capacity Barriers explained 16.88% of variance (eigenvalue = 3.714, $\alpha = 0.881$) and loaded five barriers: low client awareness (0.843), limited professional knowledge (0.826), absence of CPD (0.809), inadequate curriculum content (0.787), and lack of skilled workforce (0.764). The high loadings confirm that these barriers are operationally linked; a practitioner deficient in sustainable design knowledge is simultaneously unlikely to encounter client demand, receive CPD support, or work alongside skill-developed colleagues, creating compounding adoption barriers consistent with Rogers' (2003) complexity and trialability attributes.

Factor 3: Behavioural and Technical Barriers contributed 19.07% of variance (eigenvalue = 4.196, $\alpha = 0.871$) and loaded ten barriers spanning resistance to change (0.839), short-term client orientation (0.817), poor stakeholder coordination (0.794), absent performance monitoring (0.772), difficulty quantifying long-term benefits (0.749), limited LCA software access (0.724), absence of architect incentives (0.698), lack of local demonstration projects (0.671), inadequate supply chain infrastructure (0.644), and climate change knowledge deficit (0.617). The breadth and coherence of this factor confirm that behavioural resistance and technical tool accessibility are systematically co-occurring; practitioners resisting conventional practice departure are simultaneously less likely to access technical tools or engage sustainability benchmarks, consistent with Akindele *et al.*'s (2023) PLS-SEM finding that behavioural and technical barriers require integrated, multi-strategy interventions for effective resolution in Nigeria.

5. DISCUSSION

The empirical findings reveal a structured, three-tiered barrier architecture that systematically constrains the integration of sustainable architectural design strategies (SADS) among construction professionals in South-South Nigeria, with important theoretical and practical implications that extend beyond descriptive barrier identification. The predominant trend emerging from Table 3 is the absolute dominance of Financial and Institutional Barriers as the most critical and consistently perceived impediments: seven of the nine highest-ranked barriers belong to either the financial or institutional cluster, and Factor 1 recorded the highest eigenvalue (5.382) and internal reliability ($\alpha = 0.906$) of the three extracted factors. This structural primacy of financial and institutional barriers is not coincidental but reflects the systemic economic and governance conditions of the South-South zone. The petrochemical-driven economy generates volatile construction procurement cycles in which long-term sustainability investment horizons are consistently subordinated to short-term cost pressures; green financing mechanisms remain absent at both state and federal levels despite Nigeria's commitment to the Paris Agreement; and the lack of mandatory green building codes removes the institutional signal that would normalise sustainable design as a professional expectation rather than a discretionary premium. The practical consequence is that even professionals with sustainability knowledge and intent encounter structural disincentives that render adoption economically irrational. Within Rogers' (2003) DoI framework, these barriers collectively and systematically undermine the perceived relative advantage of sustainable strategies, making them appear economically and institutionally irrelevant in a context lacking supportive regulatory and market infrastructure. The results corroborate the conclusions of Eze *et al.* (2023) and Aghimien *et al.* (2020), who identified financial and regulatory barriers as dominant across Nigerian construction contexts, and extend them by confirming their operation specifically in the South-South zone, a context that has not previously been empirically distinguished from national-level analyses. Oyewobi and Jimoh (2022) similarly confirmed that regulatory absence and conventional cost structures are the

primary systemic enablers of unsustainable construction practice in Nigeria, reinforcing the present study's findings.

A second key result of this study is the high salience of Awareness and Capacity Barriers (Factor 2), with all five items in this cluster exceeding MIS = 3.86 and collectively achieving a Cronbach's α of 0.881, confirming that these barriers are not merely co-occurring but operationally interdependent. The root of this cluster lies in the educational and professional formation pipeline serving the South-South built environment: sustainable design content remains insufficiently embedded in Nigerian built environment curricula (MIS = 3.86, Rank 11); CPD programmes do not mandate sustainability competencies (MIS = 3.91, Rank 10); and the low proportion of clients actively demanding green buildings (MIS = 4.14, Rank 6) provides no market incentive for unilateral professional skill investment by practitioners who must bear the cost of self-directed learning without any assured commercial return. This interdependency is theoretically important: a practitioner deficient in sustainable design knowledge cannot respond to client demand even when that demand materialises, while a client population unexposed to locally demonstrated sustainable buildings cannot generate informed demand in the first instance. The resulting cycle, no knowledge, no demand, no demonstration projects, no incentive for learning, represents a self-reinforcing adoption trap consistent with Rogers' (2003) complexity and trialability dimensions. Comparing with prior studies, Mba *et al.* (2024) quantified an identical awareness-implementation gap at the national level, finding fewer than one-third of Nigerian practitioners consistently applying sustainable strategies. Agboola *et al.* (2023) confirmed that the lack of understanding of green building technologies ranked first among obstacles to acceptance in Nigeria. The present study anchors these national findings specifically in the South-South zone, where the additional absence of local demonstration projects (MIS = 3.48, Rank 20) further limits the observability dimension of adoption, creating a compounding awareness deficit unique to this geographically isolated professional community.

The third key result is the emergence of Behavioural and Technical Barriers (Factor 3) as the most structurally complex factor in the study, loading ten of the 22 barrier items and explaining 19.07% of variance, a breadth that signals the pervasive but comparatively less severe nature of these barriers relative to the financial and institutional cluster. The co-clustering of behavioural resistance and technical barriers within a single factor is theoretically coherent within Rogers' (2003) observability attribute: practitioners lacking access to energy modelling and LCA software tools cannot generate or communicate performance evidence that would motivate either their own practice change or client demand, while practitioners resistant to departing from conventional practice are simultaneously unlikely to invest in acquiring new technical capabilities. The result is a mutually reinforcing adoption barrier dynamic in which behavioural inertia and technical inaccessibility sustain each other in the absence of regulatory or market pressure from Factor 1. This finding has a critical methodological implication: interventions targeting behavioural barriers in isolation, such as awareness campaigns or motivational professional development, are likely to produce limited adoption gains unless they are simultaneously paired with interventions that expand technical tool accessibility, including subsidised LCA software, open-access energy modelling platforms calibrated for Nigerian climate data, and locally funded demonstration projects that raise observability of sustainable design outcomes. When compared to analogous findings, Akindele *et al.* (2023) confirmed using PLS-SEM that behavioural and knowledge barriers require integrated, multi-strategy interventions for effective resolution in Nigeria, while Al-Otaibi *et al.* (2025) established in Ghana and Saudi Arabia that technical expertise limitations and regulatory weaknesses act as mutually reinforcing constraints, a pattern replicated in the present study's factor structure. Fitriani and Ajayi (2022) further demonstrated in an Indonesian context that raising professional awareness is a necessary but insufficient driver of sustainable design adoption; regulatory reform and financial framework development must accompany behavioural and technical interventions. The Kruskal-Wallis results additionally confirm that barrier perceptions are differentially distributed by professional group ($H = 21.483$, $p = 0.001$), with Builders experiencing the highest perceived barrier burden, a finding that

necessitates body-specific, profession-differentiated capacity-building interventions across the South-South built environment rather than generic cross-professional sustainability programmes.

6. CONCLUSION

The integration of sustainable architectural design strategies in the South-South geopolitical zone of Nigeria is constrained by a high overall burden of barriers, a critical problem in a tropical, rapidly urbanising, petrochemical-economy region where the dual imperatives of climate adaptation and energy efficiency demand urgent sustainable design responses, yet where no prior empirical study has investigated the specific barriers operating on construction professionals in this distinct context. This study addressed that gap by examining the barriers perceived by 300 construction professionals across the six states of the zone, employing mean item scores, Kruskal-Wallis H testing, and exploratory factor analysis. The findings confirm that 19 of the 22 identified barriers were significant (MIS $\geq$ 3.50), with a grand mean of 3.90 indicating a high overall barrier burden. The most critical barriers were concentrated in the financial and institutional cluster, high material costs (MIS = 4.51), inadequate green financing (MIS = 4.43), and weak regulatory frameworks (MIS = 4.37), confirming that structural macro-level constraints constitute the most acute impediments to sustainable design integration in the study area. Factor analysis extracted three statistically robust, internally reliable latent barrier clusters: Financial and Institutional Barriers (24.46% variance, α = 0.906), Awareness and Capacity Barriers (16.88%, α = 0.881), and Behavioural and Technical Barriers (19.07%, α = 0.871), collectively explaining 60.41% of total variance. Each cluster maps directly onto Rogers' (2003) Diffusion of Innovations Theory adoption attributes, relative advantage, complexity, and observability, respectively, thereby generating a theoretically grounded, empirically validated barrier typology that is both diagnostic and prescriptive. The Kruskal-Wallis test confirmed significant inter-professional differences in barrier perception (H = 21.483, df = 4, p = 0.001), with Builders registering the highest mean rank (162.48), affirming that the barrier burden is not uniformly experienced across professional disciplines and that undifferentiated sustainability interventions are likely to be inefficient.

These findings carry substantive and actionable implications for three key stakeholder groups. For policymakers at state and federal levels, the absolute dominance of financial and institutional barriers demands: (a) the urgent enactment of mandatory minimum green building performance standards for the South-South zone, aligned with Nigeria's nationally determined contributions under the Paris Agreement; (b) the establishment of state-level green financing windows and tax-incentive frameworks that reduce the upfront cost burden of sustainable materials and technologies; (c) the integration of mandatory sustainability criteria into public-sector building procurement, thereby creating demand-side pressure that complements supply-side regulatory reform; and (d) the development of regionally specific sustainable material supply chain infrastructure to address the localised availability gaps identified in this study.

For professional bodies, NIA, NIOB, NIQS, and NSE, the significant inter-professional variation in barrier severity requires body-specific, targeted responses rather than generic cross-professional sustainability programmes. Specifically, NIOB should prioritise CPD modules addressing sustainable material procurement and site-level construction practices; NIA should introduce mandatory sustainable design competency requirements in its professional licensing pathway; NIQS should develop lifecycle cost assessment frameworks adapted to South-South Nigerian market conditions; and NSE should integrate green infrastructure design into its continuing education offerings. Joint inter-body advocacy to state and federal regulators for green building code enactment represents a further high-impact, low-cost intervention that all four bodies can pursue collectively.

For tertiary institutions offering built environment programmes across the South-South zone, the awareness and capacity barrier findings mandate curriculum reform to embed LCA methodologies, energy modelling using climate-calibrated tools, passive bioclimatic

design for hot-humid tropical conditions, and lifecycle thinking from the undergraduate level. The establishment of industry-linked sustainable building demonstration projects on institutional campuses, directly addressing the observability deficit identified in this study, would simultaneously serve as pedagogical resources and public-awareness platforms.

The study carries four principal limitations that qualify the scope of its conclusions. First, the cross-sectional design captures barrier perceptions at a single point in time, precluding assessment of how the barrier landscape evolves in response to policy changes or market developments. Second, self-reported Likert-scale responses are susceptible to social desirability bias, particularly in a professional survey context where respondents may moderate their ratings to align with perceived professional norms. Third, while the 300-respondent sample achieved adequate statistical power for the analytical methods employed, the exclusion of informal-sector construction actors and client-side stakeholders (developers, financiers, and public sector clients) limits the comprehensiveness of the barrier picture. Fourth, the study did not capture the relative severity of barriers as experienced at the project level, which may differ from the professional-population-level perceptions reported here. Future research should employ longitudinal survey designs to track barrier evolution following specific policy interventions; mixed-methods approaches integrating qualitative case studies to illuminate the lived experience of barrier navigation among practitioners; post-occupancy evaluation studies of the few existing sustainable buildings in the South-South zone to generate performance evidence that can inform the observability attribute of the DoI framework; and Partial Least Squares Structural Equation Modelling (PLS-SEM) to quantify the causal pathways through which specific barrier clusters influence measurable sustainable design integration outcomes. Comparative studies extending the barrier typology developed here to other geopolitical zones of Nigeria would further test the generalisability of the three-factor structure and strengthen the evidence base for national-level sustainable construction policy reform.

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