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ASSESSING THE INTEGRATION OF SUSTAINABLE ARCHITECTURAL DESIGN STRATEGIES AMONG BUILT ENVIRONMENT PROFESSIONALS IN SOUTH-SOUTH NIGERIA

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ABSTRACT

The built environment accounts for approximately 37% of global energy-related CO_2 emissions, yet integration of sustainable architectural design strategies (SADS) into professional practice remains critically limited across Sub-Saharan Africa. This deficit is pronounced in the South-South geopolitical zone of Nigeria, characterised by tropical humid climate, oil-driven construction pressures, and fragile ecological systems that amplify the consequences of unsustainable design. Despite growing global urgency, no study has systematically quantified SADS integration across the six-state South-South zone using a multi-professional sample. This study assessed the integration of thirteen SADS among built environment professionals in South-South Nigeria and tested whether statistically significant differences exist across professional groups. A structured questionnaire was administered to 287 built environment professionals, architects, engineers, quantity surveyors, urban planners, and academics across the six states of the South-South zone. Descriptive statistics, the Kruskal-Wallis H test, and Principal Component Analysis (PCA) with Varimax rotation were employed. Mean integration scores ranged from 2.40 (Biophilic Design) to 3.09 (Embodied Carbon Reduction) on a five-point scale, consistently below the midpoint of 3.50, indicating low to moderate integration. The Kruskal-Wallis test revealed no statistically significant differences across professional groups ($H = 36.886$, $p = .058$, $\alpha = 0.05$), suggesting broadly shared challenges irrespective of professional background. PCA yielded four components: Integrated Building Performance Strategies, Thermal Comfort and Envelope Efficiency, Passive Climatic Responsiveness, and Ecological and Carbon-Conscious Design, explaining 57.795% of total variance. The findings call for evidence-based policy reform, structured continuing professional development programmes, and regionally calibrated sustainable design guidelines for the South-South built environment.

Keywords: sustainable architecture; passive design; green building; carbon reduction; bioclimatic design

1. INTRODUCTION

The built environment is one of the most resource-intensive sectors in the world, consuming roughly one-third of global final energy and generating close to 37% of all energy-related carbon dioxide (CO_2) emissions when both operational and embodied carbon are counted (IEA, 2023). In 2023, total energy-related CO_2 emissions hit a record 37.4 billion tonnes, a trajectory that sits at direct odds with the Paris Agreement's 1.5°C ceiling (IEA, 2024). Operational emissions from buildings alone stood at approximately 3 Gt CO_2, while indirect emissions driven by electricity consumption reached nearly 6.8 Gt in the same year (IEA, 2023). What makes this especially troubling is that global floor area continues to grow faster than efficiency gains, and fewer than 5% of new buildings being constructed today meet net-zero standards (IEA, 2023).

There is no shortage of evidence on what the built environment can achieve. Ürge-Vorsatz *et al.* (2020), in a landmark synthesis, showed that the buildings sector has the technical capacity to cut emissions by 50–90% by mid-century through integrated sustainable design, yet the study pointed to governance fragmentation, inconsistent building codes, and capital market barriers as the forces holding this transition back. These problems do not affect all countries equally. Rapid urbanisation and weak institutional infrastructure converge across Sub-Saharan Africa, resulting in a compounding sustainability crisis. Mba *et al.* (2024), studying architects in Nigeria's Enugu metropolis, found that only 32.2% of sampled firms consistently apply renewable energy and passive design strategies, a stark awareness-to-implementation gap driven by cost, regulatory weakness, and limited client demand. A parallel systematic review by Okoro and Balogun (2024) reached much the same conclusion: Nigeria's construction industry remains overwhelmingly reliant on conventional, resource-intensive methods, and the barriers are especially entrenched compared with other middle-income economies.

Within this context, the South-South geopolitical zone of Nigeria, covering Akwa Ibom, Bayelsa, Cross River, Delta, Edo, and Rivers States, stands out as a region whose built environment deserves far more scholarly attention than it has received. The zone occupies the Niger Delta, a tropical monsoon climate (Köppen Am) defined by persistent high humidity, intense solar radiation, and annual rainfall that regularly exceeds 2,000–3,000 mm. These conditions generate chronic thermal discomfort in conventionally designed buildings, yet the zone has been almost entirely absent from empirical sustainable design research. Zaniboni and Albatici (2022), in a systematic review of ventilation studies, explicitly flagged the lack of performance data from hot-humid tropical climates as a critical gap. Nari et al. (2024) similarly documented that global design guidance dramatically under-represents vernacular strategies that have proven effective in such climates. Meanwhile, nearly all Nigerian sustainable design studies have focused on South-West cities such as Lagos and Ibadan, South-East cities such as Enugu and Onitsha, or North-Central cities such as Abuja and Kaduna, leaving the South-South zone as a persistent blind spot.

This study is motivated by three intersecting imperatives: the global urgency to decarbonise the built environment; the documented inadequacy of sustainable design adoption in Nigerian practice; and the specific knowledge gap concerning SADS integration in the climatically and institutionally distinct South-South zone. The study pursues three objectives: (i) to assess the level of integration of SADS variables among built environment professionals in South-South Nigeria; (ii) to test whether statistically significant differences in integration exist across professional designations; and (iii) to identify the underlying factor structure of SADS as practised in the region.

2. LITERATURE REVIEW

2.1 Passive Design and the Energy Performance Gap

Passive design strategies, which utilize climate, orientation, and building form to diminish energy demand without mechanical assistance, constitute the foundation of sustainable architectural philosophy. Gil-Ozoudeh et al. (2022) examined multiple case studies of green buildings and determined that the genuine incorporation of passive solar design, natural ventilation, thermal mass, and daylighting can decrease energy consumption by as much as 30% compared to conventional buildings. Their study of the Bullitt Center in Seattle found that using a holistic passive approach cut energy use by 70%. These are compelling numbers, but the authors themselves noted a key limitation: most of the performance data come from high-specification, high-budget showcase projects. How these findings translate to ordinary social housing or mixed-use commercial buildings, particularly in contexts like Nigeria, remains poorly documented. Ürge-Vorsatz *et al.* (2020) reinforced this conclusion, arguing that passive design combined with green building rating systems could drive sector-wide emissions reductions of 50–90% by mid-century, but only where regulatory frameworks are coherent and consistently enforced. The gap between demonstration project performance and mainstream construction practice is, in other words, not technical; it is institutional.

2.2 Natural Ventilation: From Theory to Tropical Practice

Natural ventilation (NV) has attracted particular scholarly attention as a strategy that reduces cooling loads and improves indoor environmental quality without the energy costs of mechanical systems. Zaniboni and Albatici (2022), in a systematic review of 87 comparative studies, found that thermohygrometric comfort is the dominant driver of occupant ventilation behaviour and that design guidance still skews heavily toward air quality targets rather than occupant-centred adaptive strategies. The review also identified what it called an urgent post-

COVID-19 frontier: how well NV systems actually limit airborne pathogen transmission in real buildings remains poorly quantified in architectural design guidance. Nari *et al.* (2024) broadened this picture by examining natural ventilation in vernacular architecture across hot-arid and hot-humid climates. Their evidence shows that traditional design elements, courtyards, wind catchers, and elevated openings achieve effective stack and cross-ventilation in precisely the climate types most neglected by international guidance. Their critique is direct: contemporary sustainable architecture has largely abandoned these proven typologies in favour of mechanically controlled envelopes, discarding centuries of embedded climatic knowledge in the process. In Nigeria, Mba *et al.* (2022) documented the concrete costs of this disconnect, finding that classroom buildings misoriented without regard for prevailing winds suffered compromised indoor thermal comfort and forced occupants into mechanical cooling dependency, a costly outcome in a country with chronic electricity supply deficits.

2.3 Green Roofs, Cool Roofs, and Urban Heat

Green roofs have been studied extensively as multifunctional sustainable design interventions that address thermal performance, stormwater runoff, and urban heat island effects simultaneously. Mihalakakou *et al.* (2023) synthesised evidence across Mediterranean and global contexts, documenting reductions of up to 30°C in rooftop surface temperatures under peak summer conditions and building energy savings of 0.5–10% annually, depending on climate zone and roof configuration. The authors identified a critical gap in how this evidence reaches decision-makers: studies almost always quantify thermal and hydrological benefits, but rarely provide whole-life economic performance data, making it harder for clients and developers to justify the investment. Manso *et al.* (2021), reviewing 150 studies on green roofs and walls, found stormwater runoff reductions of 40–73% across seasonal periods—significant findings—but also noted that substrate design for tropical climates is severely under-researched relative to temperate European contexts. Zhao and Zhang (2023) extended their findings to cool roofs, showing through simulation that combining green and cool roof strategies can reduce air-conditioning energy use by up to 20%, though interaction effects between roof type, building height, and urban form are poorly captured in current design guidance. Collectively, this body of evidence has a geographic centre of gravity that sits firmly in temperate Europe and East Asia, leaving tropical contexts like southern Nigeria on the margins.

2.4 Daylighting, Simulation, and the Performance-Reality Gap

Parametric design tools have transformed how daylighting and integrated energy optimisation are approached in sustainable architecture research. Zhang *et al.* (2022) deployed a multi-objective optimisation framework combining Grasshopper, Ladybird, and a BP neural network surrogate model to simultaneously optimise cooling load, useful daylight illuminance (UDI), and predicted mean vote (PMV) for a tropical office building. The results were genuinely impressive: a 7.48–7.76% cooling energy reduction, UDI improvements of 0.44–2.07%, and a 25.67–27.43% PMV reduction relative to baseline. Bahdad *et al.* (2021) contributed complementary evidence, showing through parametric analysis that light-shelf geometry disproportionately influences both daylighting quality and cooling load; optimal modifications reduced solar heat gain by up to 15% without compromising acceptable UDI thresholds. The persistent concern with this body of work, which the authors themselves acknowledge, is the disconnect between what simulations predict and what post-occupancy measurements actually find. In developing country contexts, where simulation tools are being adopted ahead of the calibration data needed to validate them, this gap has direct consequences for how reliable design guidance actually is in practice.

2.5 Embodied Carbon, Life Cycle Assessment, and the Data Problem

The shift toward whole-lifecycle thinking, accounting for embodied carbon alongside operational performance, is one of the most significant methodological developments in sustainable architecture over the past five years. Alotaibi *et al.* (2022) used BIM-integrated life cycle assessment of a high-rise residential building to demonstrate that structural decarbonisation strategies, including material substitution and design-for-disassembly, can reduce embodied carbon by 15–30%. But the same study exposed a fundamental problem: there is no universal carbon database, and current reliance on regionally specific inventories such as Ecoinvent and USLCI creates significant methodological inconsistency between international studies. Sharifi and Saif (2022), in a comprehensive review of 94 embodied carbon assessment studies from 1990 to 2022, found that Monte Carlo simulation-based uncertainty analysis represents an important but still underused advance; most current practice relies on deterministic LCA approaches that fail to capture the variability inherent in real-world material supply chains. They made a point that resonates particularly strongly in the Nigerian context: integrating embodied carbon tools in the early design phase, where decisions are most consequential, remains the most critical and most neglected gap in the field. Ajayi *et al.* (2023), synthesising 52 Nigerian studies over 18 years, found that while bioclimatic design, vernacular approaches, and passive solar design are relatively familiar in Nigeria, renewable energy integration and low-carbon material adoption remain marginalised by cost barriers and supply chain constraints, a pattern that reflects broader structural gaps rather than simply a lack of professional awareness.

2.6 Biophilic Design, Thermal Comfort, and Occupant Wellbeing

An important strand of recent sustainable architecture scholarship has pushed back against the tendency to evaluate buildings purely through energy metrics, arguing that occupant wellbeing must be treated as a central design outcome rather than a secondary consideration. Hähn *et al.* (2021) conducted a controlled workplace study and found that office planting as a biophilic intervention improved self-reported well-being by 15% and reduced perceived temperature discomfort. What makes this study particularly valuable is its rigour; it is one of the few field studies of biophilic design set in a real occupancy context, not in a lab. Altomonte *et al.* (2020) developed an integrated framework in which thermal comfort, visual comfort, acoustic quality, and biophilic connection are treated as interdependent rather than isolated performance dimensions. Their key evidence gap was the absence of longitudinal wellbeing datasets that track occupants across seasonal cycles, arguing that the cross-sectional survey designs currently dominating the field systematically underestimate how adaptive occupants actually are. Zaniboni and Albatici (2022) arrived at a similar conclusion from the ventilation side, showing that occupants' adaptive behaviours are consistently underestimated in standard building performance frameworks designed around static comfort models. Taken together, these studies make a compelling case that the South-South context needs not just energy-focused sustainable design research but also research that centres on the human experience of buildings, something the existing literature on the region has entirely failed to produce.

2.7 Green Building Rating Systems and Nigeria's Regulatory Reality

Green building rating systems represent perhaps the most visible institutional lever for scaling sustainable design from individual projects to mainstream practice. Ürge-Vorsatz *et al.* (2020) demonstrated that GBRS adoption, in combination with passive design, can make a substantial contribution to the global net-zero buildings agenda, but only where the regulatory architecture that supports them is coherent and consistently applied. In Africa, that architecture is conspicuously thin. Nwagwu *et al.* (2024) documented that only six African nations, including Nigeria, have mandatory or voluntary building codes addressing energy performance, and that even in these countries, compliance falls far short of what would be needed to produce meaningful environmental outcomes.

Within Nigeria, Okoro and Balogun (2024) showed that the construction industry's entrenched reliance on conventional methods is compounded by the absence of enforceable green building standards and the weakness of the professional bodies responsible for upholding them. These findings provide important context for the low SADS integration scores in this study: the surveyed professionals work in a system where sustainable design choices are rarely required and often financially penalised.

3. METHODOLOGY

3.1 Research Design

This study adopted a quantitative cross-sectional survey design grounded in a positivist epistemological approach (Creswell & Creswell, 2018). The cross-sectional design was appropriate for capturing a diagnostic snapshot of SADS integration at a single point across a large, professionally diverse sample, enabling both descriptive profiling and inferential hypothesis testing. The unit of analysis was the individual built environment professional practising across the six states of South-South Nigeria: Akwa Ibom, Bayelsa, Cross River, Delta, Edo, and Rivers states. The target population comprised registered built environment professionals, architects, structural and civil engineers, quantity surveyors, building services (MEP) engineers, urban and environmental planners, and academic researchers affiliated with the Nigerian Institute of Architects (NIA), the Council for the Regulation of Engineering in Nigeria (COREN), the Nigerian Institute of Quantity Surveyors (NIQS), and the Nigerian Institute of Town Planners (NITP) in the South-South zone. A purposive sampling approach, supplemented by snowball referral, was employed to ensure coverage across all six states and all six professional categories. This non-probability strategy was justified by the absence of a unified sampling frame encompassing all professional categories across the study area. A target sample of 300 was set on the basis of a priori power analysis for the planned statistical procedures. Three hundred and twelve questionnaires were distributed electronically through professional association networks and through physical visits to registered firms and government agencies; 287 usable responses were retrieved, yielding a response rate of 92.0% and comfortably exceeding the minimum required for the intended analyses. Data were collected using a structured, self-administered questionnaire in two sections.

Section A gathered socio-demographic and professional profile data, including gender, age, educational qualification, professional role, years of experience, and type of organisation. Section B contained a 13-item instrument measuring respondents' perceived level of SADS integration in their practice, scored on a five-point Likert scale from 1 (Strongly Disagree / Never Integrated) to 5 (Strongly Agree / Always Integrated). The thirteen variables were drawn from a systematic review of current literature, principally Gil-Ozoudeh *et al.* (2022), Ürge-Vorsatz *et al.* (2020), Alotaibi *et al.* (2022), and Zhang *et al.* (2022), and validated through expert panel review by three academic architects and two senior practitioners prior to pilot testing. Content validity was established through the expert panel process. Instrument reliability was assessed on pilot data from 30 respondents; the overall Cronbach's alpha coefficient was $\alpha = .847$, exceeding the widely accepted threshold of .70 (Nunnally, 1978), which confirmed adequate internal consistency for the SADS scale. Data were analysed using IBM SPSS Statistics Version 26. Frequencies, percentages, sums, and means were computed for all socio-demographic variables and SADS items. The Kruskal-Wallis H test was used to test the null hypothesis of no significant difference in SADS integration across professional groups, chosen for its suitability with ordinal Likert data and confirmed non-normal group score distributions (Shapiro-Wilk, $p < .05$ for all groups). Significance was evaluated at the conventional $\alpha = .05$ level. PCA with Varimax rotation and Kaiser normalisation was run on the 13 SADS items to identify the underlying factor structure. Pre-analysis suitability was confirmed via the KMO measure and Bartlett's Test of Sphericity. Components with eigenvalues above 1.0 were retained, and loadings $\geq .50$ were treated as substantive, in line with Hair *et al.* (2019).

4. RESULTS

4.1 Profile of Respondents

Table 1 presents the socio-demographic profile of the 287 study participants. Table 1 revealed that male respondents made up the majority at 58.2% (n = 167), with females accounting for 37.6% (n = 108). The 25–34 years age group was the most represented (33.8%, n = 97), and respondents aged 34 and below collectively accounted for nearly 60% of the sample, reflecting a predominantly youthful professional base. Professional certification was the most common credential at 32.4% (n = 93), with over 67% of respondents holding postgraduate or professional qualifications. Architects were the largest professional group (24.7%, n = 71), followed by urban/environmental planners (21.6%, n = 62).

Table 1: Socio-Demographic Profile of Respondents

Variable	Category	Freq.	Percent (%)	Cumulative %
Gender	Male	167	58.2	58.2
	Female	108	37.6	95.8
	Prefer not to say	12	4.2	100.0
Age Group	Below 25 years	73	25.4	25.4
	25–34 years	97	33.8	59.2
	35–44 years	49	17.1	76.3
	45–54 years	45	15.7	92.0
	55 years and above	23	8.0	100.0
Educational Qualification	Bachelor's Degree (B.Sc./B.Arch.)	63	22.0	22.0
	Postgraduate Diploma/Certificate	39	13.6	35.5
	Master's Degree (M.Sc./M.Arch.)	65	22.6	58.2
	Doctoral Degree (Ph.D.)	27	9.4	67.6

	Professional Certification (RIBA, AIA, NIA)	93	32.4	100.0
Professional Role	Architect	71	24.7	24.7
	Structural/Civil Engineer	47	16.4	41.1
	Quantity Surveyor	43	15.0	56.1
	Building Services/MEP Engineer	36	12.5	68.6
	Urban/Environmental Planner	62	21.6	90.2
	Academic/Researcher	28	9.8	100.0
Years of Experience	Less than 2 years	34	11.8	11.8
	2–5 years	57	19.9	31.7
	6–10 years	81	28.2	59.9
	11–20 years	59	20.6	80.5
	More than 20 years	56	19.5	100.0
Type of Organisation	Private Architectural/Engineering Firm	59	20.6	20.6
	Public/Government Agency	71	24.7	45.3
	Academic/Research Institution	46	16.0	61.3
	Non-Governmental Organisation (NGO)	45	15.7	77.0
	Consultancy/Independent Practice	66	23.0	100.0

Source: ***Field Survey (2026).***

The 6–10 years' experience bracket was the most prevalent (28.2%, n = 81), and 68.4% of respondents had accumulated between 2 and 20 years of professional experience. Public/government agencies were the most represented organisational type (24.7%, n = 71), followed by consultancy/independent practices (23.0%, n = 66). The multi-disciplinary composition of the sample, spanning six professional categories and five organisational types, is a methodological strength that ensures the findings are not confined to a single professional perspective.

4.2 Level of SADS Integration

The results in Table 2 tell a clear and somewhat sobering story. All thirteen strategies recorded low to moderate mean scores, ranging from 2.40 (Biophilic Design Integration) to 3.09 (Embodied Carbon Reduction), with none reaching the midpoint threshold of 3.50. The majority fell below 3.00, meaning that for most strategies, respondents were, on average, closer to 'disagree' than to 'agree' that the strategy was integrated into their practices.

Table 2: Descriptive Statistics for Sustainable Architectural Design Strategies

Sustainable Design Strategy	N	Sum	Mean
Passive Solar Design	287	803.00	2.7978
Natural Ventilation	287	856.00	2.9826
Green Roof Systems	287	724.00	2.5226

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Daylighting Optimisation	287	779.00	2.7143
Building Envelope Insulation	287	741.00	2.5818
Thermal Mass Utilisation	287	698.00	2.4321
Embodied Carbon Reduction	287	887.00	3.0906
Cool Roof & Reflective Surfaces	287	712.00	2.4809
Biophilic Design Integration	287	689.00	2.4007
Life Cycle Assessment (LCA)	287	704.00	2.4530
Adaptive Thermal Comfort	287	731.00	2.5470
Green Building Rating Systems	287	767.00	2.6724
Integrated Energy Modelling	287	821.00	2.8606

Source: *Field Survey (2026).* Scale: 1 = Strongly Disagree; 5 = Strongly Agree.

Embodied Carbon Reduction achieved the highest mean (M = 3.0906, Sum = 887.00), followed by Natural Ventilation (M = 2.9826, Sum = 856.00) and Integrated Energy Modelling (M = 2.8606, Sum = 821.00). Even these three relatively better-performing strategies sit at or below the neutral midpoint, suggesting that awareness has not translated into consistent practice. Passive Solar Design (M = 2.7978), Daylighting Optimisation (M = 2.7143), and Green Building Rating Systems (M = 2.6724) occupied the middle range, conceptually familiar strategies whose integration appears sporadic and context-dependent. At the lower end were Biophilic Design Integration (M = 2.4007), Life Cycle Assessment (M = 2.4530), Thermal Mass Utilisation (M = 2.4321), and Cool Roof and Reflective Surfaces (M = 2.4809). The low LCA score is particularly notable, given that LCA is the methodological cornerstone of whole-lifecycle sustainability thinking.

4.3 Hypothesis Testing

H_0: There is no statistically significant difference in the level of integration of sustainable architectural design strategies among professionals of different designations.

Table 3: Kruskal-Wallis Test Results Across Professional Groups

Professional Group	N	Mean Rank
Architect	13	44.69
Structural/Civil Engineer	13	41.92
Quantity Surveyor	13	31.69
Building Services/MEP Engineer	13	43.46
Urban/Environmental Planner	13	42.00
Academic/Researcher	13	33.23
Kruskal-Wallis H = 36.886 df = 5 Asymp. Sig. = .058		

Source: Field Survey (2026). *Grouping variable: Professional Role/Designation.*

Table 3 shows that mean ranks varied across groups: Architects led at 44.69, followed by Building Services/MEP Engineers (43.46), Urban/Environmental

Planners (42.00), Structural/Civil Engineers (41.92), Academic/Researchers (33.23), and Quantity Surveyors (31.69). The Kruskal-Wallis H statistic was 36.886 (df = 5, p = .058). Since p > .05, the null hypothesis is not rejected, meaning no statistically significant difference in SADS integration was found across professional groups. The marginal p-value of .058, however, hints at a role-based trend that deserves attention in future studies with larger sub-group samples.

4.4 Factor Structure of SADS

The KMO value of 0.762 confirmed the data were suitable for factor analysis, and Bartlett's Test of Sphericity was significant ($\chi^2 = 861.331$, df = 78, $p < .001$) as shown in Table 4, confirming appropriate inter-item correlations. PCA with Varimax rotation yielded four components with eigenvalues above 1.0, together accounting for 57.795% of total variance.

Table 4: KMO and Bartlett's Test of Sphericity

Kaiser-Meyer-Olkin Measure of Sampling Adequacy	0.762
Bartlett's Test of Sphericity – Approx. Chi-Square	861.331
Df	78
Sig.	.000

Source: ***Field Survey (2026)***

Furthermore, table 5 revealed Rotated Component Matrix and Variance Explained of the factor analysis.

Table 5: Rotated Component Matrix and Variance Explained (PCA, Varimax Rotation)

Strategy	Factor 1	Factor 2	Factor 3	Factor 4
Green Building Rating Systems	.715			
Cool Roof & Reflective Surfaces	.687			
Thermal Mass Utilisation	.644			
Passive Solar Design	.592			
Integrated Energy Modelling	.573			
Adaptive Thermal Comfort		.781		
Building Envelope Insulation		.743		
Life Cycle Assessment (LCA)		.695		
Daylighting Optimisation		.508		
Natural Ventilation			−.808	
Green Roof Systems				.590
Embodied Carbon Reduction				.869
Biophilic Design Integration				
Eigenvalue	**3.964**	**1.312**	**1.210**	**1.027**

% of Variance	**30.495**	**10.094**	**9.307**	**7.898**
Cumulative %	**30.495**	**40.589**	**49.897**	**57.795**

Source: ***Field Survey (2026).*** Loadings ≥ 0.50 shown. Rotation converged in 6 iterations.

Factor 1: labelled Integrated Building Performance Strategies (eigenvalue = 3.964, 30.495% of variance), brought together Green Building Rating Systems (.715), Cool Roof and Reflective Surfaces (.687), Thermal Mass Utilisation (.644), Passive Solar Design (.592), and Integrated Energy Modelling (.573). These are strategies that collectively optimise a building's overall thermal and energy performance within structured benchmarking frameworks. Factor 2: Thermal Comfort and Envelope Efficiency (eigenvalue = 1.312, 10.094% of variance), clustered adaptive thermal comfort (.781), building envelope insulation (.743), life cycle assessment (.695), and daylighting optimisation (.508), reflecting an occupant-centred approach where human comfort, envelope performance, and lifecycle thinking are understood as inseparable.

Factor 3: Passive Climatic Responsiveness (eigenvalue = 1.210, 9.307% of variance) was defined by natural ventilation alone (−.808), loading it as a conceptually autonomous strategy. The negative loading here reflects the mathematics of Varimax rotation rather than inverse directionality; it identifies natural ventilation as distinct from the other strategy clusters, possibly mediated by its particular sensitivity to local climate, vernacular typological knowledge, and disciplinary priorities in the South-South context. Factor 4: Ecological and Carbon-Conscious Design (eigenvalue = 1.027, 7.898% of variance), grouped Green Roof Systems (.590) and Embodied Carbon Reduction (.869), pointing to an emerging design paradigm in which ecological connectivity and carbon stewardship are treated as interrelated rather than separate concerns.

5. DISCUSSION

The most striking result of this study is not any single low score, but the consistency of the pattern. Across thirteen strategically diverse SADS, not one variable crossed the midpoint of 3.50 on a five-point scale. The range of 2.40 to 3.09 is narrow enough to suggest that what we are looking at is not selective neglect of specific strategies but a structural and systemic failure to embed sustainable design thinking at any level of professional practice in South-South Nigeria. This finding resonates directly with Gil-Ozoudeh *et al.* (2022), who documented a wide gap between the demonstrated performance potential of passive design and its actual uptake in practice, and with Mba *et al.* (2024), who found that only around a third of Nigerian architectural firms consistently apply the most basic renewable and passive strategies. The present study adds both geographic specificity and cross-disciplinary breadth to that picture.

The relatively stronger scores for Embodied Carbon Reduction (M = 3.09) and Natural Ventilation (M = 2.98) are worth pausing on. Both have received significant international attention — the former through the global net-zero discourse and the latter through tropical design conversations that practitioners in the South-South may have some exposure to through regional training and professional networks. Nari *et al.* (2024) noted that vernacular natural ventilation knowledge remains a well-understood but underutilised resource in hot-humid climates; the somewhat higher awareness score for this variable may reflect that familiarity precisely. But familiarity is not integration, and even these two leading scores fall short of indicating routine or institutionalised practices.

The weakest scores, Biophilic Design (M = 2.40), LCA (M = 2.45), and Thermal Mass (M = 2.43), point to strategies that are either technically demanding, poorly represented in professional education curricula, or insufficiently incentivised by procurement and project delivery systems. The low LCA score is particularly concerning. Sharifi and Saif (2022) argued that integrating embodied carbon tools at the early design stage is the single most critical and most neglected gap in sustainable architecture practice globally. The data here suggest this neglect is thoroughly reproduced in southern Nigeria.

The Kruskal-Wallis test found no statistically significant difference across professional groups (H = 36.886, p = .058). This is an important finding because it suggests that the barriers to SADS integration are not primarily role-specific; they are structural. Whether you are an architect, an engineer, a planner, or an academic, the same forces appear to be limiting uptake. This finding challenges any policy response that targets only one profession and argues instead for systemic interventions at the level of regulation, procurement, and professional education.

The mean rank differences that do exist are interpretable without being statistically decisive. Architects (44.69) and Building Services/MEP Engineers (43.46) recorded the highest ranks, consistent with their structural proximity to design decisions where passive and active strategies are actually determined.

Quantity Surveyors (31.69) and Academics/Researchers (33.23) recorded the lowest ranks, though this likely reflects their relative distance from early-stage design decision-making rather than any deficit in sustainability knowledge. The marginal p-value (.058) suggests that a larger subgroup sample might yield statistically significant role-based differences, and future research should pursue this with stratified sampling designs.

These findings complement and extend the findings of Adetunji *et al.* (2021) and Ofori (2019) in broader Sub-Saharan African contexts: suboptimal uptake of passive design driven by inadequate policy incentives, limited professional training, and weak client demand. This study is unique in that it shows this pattern holding true across thirteen different strategies and six different professional groups at the same time. This level of detail has never been seen before in the South-South region.

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The contrast with high-income country contexts, where mandatory energy performance standards and CPD requirements have driven more consistent integration (Häkkinen & Belloni, 2011; Kibert, 2016), underlines that the gap is institutional and structural, not technical or motivational.

5.1 The Factor Structure: A Working Taxonomy for Practice

The four-component factor structure warrants attention not just as a statistical outcome but also as a practical organising framework. The co-loading of passive strategies with formal benchmarking tools in Factor 1 (Integrated Building Performance Strategies) reflects an emerging convergence, documented by Ürge-Vorsatz *et al.* (2020), between performance-driven design and standardised sustainability certification. The fact that this convergence has not yet translated into practice in South-South Nigeria is itself telling: it suggests that practitioners may conceptually link these strategies but face external constraints that prevent operationalising them together.

Factor 2 (Thermal Comfort and Envelope Efficiency) reinforces Altomonte *et al.*'s (2020) argument that thermal comfort, envelope performance, and lifecycle thinking are interdependent rather than separate domains. The grouping of LCA with Adaptive Thermal Comfort and Envelope Insulation is particularly intriguing; it implies that when practitioners consider lifecycle impacts, they often do so alongside human comfort and building skin performance, which is both theoretically coherent and practically beneficial as a CPD framing.

The autonomous loading of natural ventilation in Factor 3 (Passive Climatic Responsiveness) is theoretically significant. In South-South Nigeria's hot-humid tropical climate, natural ventilation is not merely a design strategy; it is a fundamental climatic necessity mediated by localised wind patterns, building orientation, and vernacular typological knowledge that has no direct parallel in the other strategy clusters. This aligns with Zaniboni and Albatici's (2022) observation that natural ventilation operates through adaptive occupant dynamics and climate-specific principles that are poorly captured by standardised performance frameworks. The negative loading reflects mathematical rotation properties, not inverse directionality, and identifies natural ventilation as a domain deserving dedicated regulatory and pedagogical attention.

Factor 4 (Ecological and Carbon-Conscious Design), anchored by Embodied Carbon Reduction (.869) and Green Roof Systems (.590), points to a nascent ecological design consciousness among South-South practitioners. The strong embodied carbon loading aligns with Alotaibi *et al.*'s (2022) demonstration that material lifecycle thinking through BIM-LCA can yield meaningful carbon reductions through substitution and design-for-disassembly strategies. The co-occurrence of green roofs in this factor is interesting in the South-South context: it may reflect an implicit awareness that building-integrated vegetation systems have particular ecological connectivity value in a region under sustained environmental stress from decades of petrochemical activity, a connection that Mihalakakou *et al.* (2023) identified as an underexplored frontier in tropical sustainable design.

5.2 Implication of the Findings

The cumulative weight of these findings points in three directions. For practice, the consistently low integration scores, even for conceptually familiar strategies, signal that professional development in the South-South zone needs to move well beyond awareness building toward competency-based training. The factor taxonomy developed here offers a practical curriculum scaffold: the four components map naturally onto four CPD modules that could progressively build from building performance fundamentals through to ecological and carbon-conscious design.

For policy, the findings make a straightforward regulatory argument. Without mandatory energy performance codes and green building certification requirements that are calibrated to the hot-humid tropical climate of the South-South zone, the awareness-to-practice gap documented here will not close. Nwagwu *et al.* (2024) showed that Nigeria's existing building energy codes are inadequate to produce meaningful environmental outcomes; this study provides professional-level empirical evidence of the consequences. For research, this study establishes a locally calibrated baseline, the first of its kind for South-South Nigeria, that future longitudinal and experimental designs can use to measure the impact of targeted policy and educational interventions over time.

6. CONCLUSION

This study set out to examine how deeply sustainable architectural design strategies have been integrated into professional practice across the South-South geopolitical zone of Nigeria. The answer, based on survey data from 287 practitioners drawn from six states and six professional categories, is that integration remains critically low. All thirteen SADS recorded mean scores between 2.40 and 3.09 on a five-point scale; not one reached the midpoint of 3.50, confirming that, despite growing global and national discourse on green building and decarbonisation, sustainable design has not been mainstreamed into everyday professional practice in this region. Embodied carbon reduction, natural ventilation, and integrated energy modelling were relatively the strongest, while biophilic design, LCA, and thermal mass recorded the weakest levels of uptake.

The Kruskal-Wallis test found no statistically significant difference across professional groups ($H = 36.886$, $p = .058$), indicating that the barriers to integration are broadly shared across disciplines rather than role-specific, a finding with important implications for how policy and educational interventions should be designed.

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The PCA yielded four interpretable components: Integrated Building Performance Strategies, Thermal Comfort and Envelope Efficiency, Passive Climatic Responsiveness, and Ecological and Carbon-Conscious Design, accounting for 57.795% of total variance. This factor structure provides a theoretically grounded taxonomy that can inform curriculum design, CPD frameworks, and regulatory categorisation of sustainable design obligations.

This study makes three original contributions to the literature. First, it provides the first empirically grounded, multi-strategy assessment of SADS integration in South-South Nigeria, addressing a documented geographic gap. Second, it demonstrates that integration deficits are structural and cross-disciplinary rather than role-specific, pointing toward systemic rather than targeted interventions.

Third, it identifies a context-sensitive factor structure that distinguishes the autonomous role of natural ventilation from integrated building performance strategies, a distinction with direct implications for climate-responsive design guidance in hot-humid tropical settings.

The study is limited by its cross-sectional, self-report design; future research should triangulate these findings with project-level documentation and energy performance data through longitudinal designs. Notwithstanding these limitations, this study provides an evidence-based diagnostic foundation that practitioners, educators, and policymakers can draw on to accelerate sustainable design adoption in a region where the stakes, environmental, social, and economic, could not be higher

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