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Research Article

Climate-Responsive Design Neglect in Contemporary Residential Buildings in Katsina State, Nigeria: Perspectives of Residents and Builders

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Abstract This study examines the neglect of climate-responsive design principles in contemporary residential buildings in Katsina State, Nigeria, a hot semi-arid region where indoor thermal comfort is increasingly affected by modern construction practices. Traditional Hausa vernacular architecture utilized passive cooling strategies, including thick mud-brick walls, courtyards, and natural ventilation, but these approaches have been largely replaced by sandcrete blocks and corrugated metal roofing. Using a mixed-methods approach, questionnaires were administered to 33 residents and builders in Katsina metropolis. Quantitative data were analyzed using descriptive statistics, while qualitative responses were examined through thematic analysis. The findings show that 76% of houses use cement/sandcrete block walls, 73% use corrugated metal roofing, 60% of residents experience hot indoor conditions, and 97% depend on mechanical cooling. Additionally, 82% spend ₦5,000–₦30,000 monthly on electricity. A key finding is that 52% of builders incorrectly perceive modern houses as cooler than traditional mud-brick structures, indicating a knowledge gap. The study highlights cost and aesthetic preferences as major factors influencing climate-insensitive material choices and recommends natural ventilation, roof insulation, shading strategies, and climate-responsive guidelines for Katsina State.

Keywords: Climate-Responsive Design; Indoor Thermal Comfort; Katsina State; Residential Buildings; Vernacular Architecture.

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1. Introduction

Katsina State, located in the north-western geopolitical zone of Nigeria, lies within a hot semi-arid climatic zone classified as BSh under the Köppen-Geiger climate classification system. The region experiences extreme daytime temperatures regularly exceeding 40°C during the dry season (November to May), characterised by low relative humidity and the harmattan wind that sweeps southward from the Sahara Desert. These climatic conditions impose significant demands on building performance, particularly regarding indoor thermal comfort, natural ventilation, and energy consumption (Givoni, 1994; Lechner, 2014).

For centuries, indigenous builders in Katsina and the wider Hausa-Fulani cultural region developed a refined vernacular architecture intuitively adapted to these extreme conditions. The traditional Hausa compound (gida) features thick mud-brick (tubali) walls of 300–600mm, deep internal courtyards (tsakar gida), small shaded openings oriented toward prevailing north-east trade winds, and high thermal mass that effectively moderates diurnal temperature swings (Moughtin, 1985; Dmochowski, 1990). These passive design strategies represent centuries of accumulated climate knowledge embedded in building form and material.

However, the post-independence era and accelerating urbanisation have produced a dramatic shift in residential construction. Sandcrete block walls, corrugated metal roofing, and imported architectural typologies now dominate new residential development across Katsina, driven by associations of concrete with modernity, low initial cost, and material availability (Aduwo et al., 2013; Vale & Vale, 1991). The thermal consequences are severe: sandcrete block walls at 150–225mm thickness have substantially lower thermal mass than mud walls; corrugated zinc roofing has near-zero insulation value and rapidly transfers solar radiation into interior spaces (Onyegiri & Abam, 2015; Dili et al., 2010).

Despite this documented problem, Katsina State remains underrepresented in focused architectural research. Most existing studies address similar issues at the broader Nigerian or West African scale, leaving a gap in localized, community-centred investigations that emphasize the perspectives of residents and builders. This study addresses this gap by combining structured questionnaires with qualitative open-ended responses to investigate the causes and consequences of climate-insensitive design practices in contemporary residential buildings in Katsina. The research aims to document dominant material and design practices, assess residents' thermal comfort experiences and energy burdens, and identify the professional and social factors influencing climate-insensitive construction decisions.

2. Literature Review

Climate-responsive architecture also termed bioclimatic or passive design seeks to integrate local climatic conditions into all aspects of building design to achieve indoor thermal comfort with minimal mechanical intervention (Olgyay, 1963; Givoni, 1994). In hot semi-arid climates, the principal design strategies include: maximising thermal mass to absorb daytime heat and release it at night; east–west building orientation to minimise east and west wall exposure to direct solar radiation; natural cross-ventilation through opposing openings aligned with prevailing winds; provision of roof overhangs and external shading; and use of materials with high thermal resistance (Fathy, 1986; Lechner, 2014).

The traditional Hausa compound exemplifies these principles in practice. Schwerdtfeger (1972) & Moughtin (1985) documented how the zaure-tsakar gida spatial sequence creates a thermally buffered progression from public to private space, with the courtyard functioning as a natural chimney for warm air evacuation and cool night air storage. Fathy (1986) & Oliver (1997) both identified this Sahelian courtyard typology as a model of climate-responsive design worthy of contemporary reinterpretation.

The failure of modern construction to replicate these performance characteristics has been extensively documented across West Africa. Aduwo et al. (2013) traced the dominance of concrete construction to post-colonial policy and urban development models that privileged industrial materials. Abimaje et al. (2013) documented specific thermal performance deficits in North-East Nigerian residential buildings, attributing them to thin concrete walls, uninsulated metal roofing, and the elimination of shading. Musa et al. (2020) measured indoor temperatures in contemporary Maiduguri residences regularly exceeding 35°C during peak afternoon hours, correlating with high fan and AC dependency. Aliyu et al. (2016) noted that energy costs for cooling represent a disproportionate financial burden for lower-income households in Northern Nigerian cities a social dimension of building performance rarely addressed in technical studies. Nwalusi et al. (2022) reached similar conclusions in the tropical environment of Enugu, finding that contemporary residential buildings have progressively abandoned eave projections, adequate headroom heights, and generous window openings that colonial-era buildings used as passive climate controls. Similarly, Alabi et al. (2025) demonstrated in south-western Nigeria that combining passive cooling strategies such as thermal mass and natural cross-ventilation remains essential in Nigerian climates characterised by persistently high temperatures and low wind speeds. The role of courtyard geometry in enabling natural ventilation has further been confirmed by Anselm & Omusi (2023), who documented how courtyard form and proportion directly influence airflow regimes in tropical Nigerian buildings findings that lend additional support to the thermal value of retained courtyard forms documented in this study. At the national scale, Alegbe & Mtaver (2023) demonstrated through energy simulation across all 36 Nigerian state capitals that without climate-responsive retrofitting, residential buildings face dramatically worsening indoor conditions under projected temperature rise scenarios underscoring the urgency of the design improvements recommended by this study.

A recurring finding across this literature is the gap between builder knowledge and practice: while awareness of climate-responsive principles may exist, economic pressures, client aesthetic preferences, and the absence of enforced building energy codes consistently override

thermal performance in decision-making (Abimaje et al., 2013). This study builds on and extends this body of work by situating it specifically in Katsina State, where comparable primary research has not previously been conducted.

3. Research Methods

This study employs a mixed-methods research design combining structured questionnaires (quantitative) with open-ended qualitative responses, following Creswell's (2014) sequential explanatory framework in which quantitative data establish the overall pattern and qualitative data provide contextual depth. This approach is appropriate for investigating both the scale of a problem and its social and professional causes within a specific built environment context.

The study area is Katsina metropolis, the capital of Katsina State, situated at approximately 12.99°N, 7.60°E, at an elevation of 519m above sea level (Figure 1 and Figure 2). Katsina State is located in the north-western geopolitical zone of Nigeria, bordered by Zamfara State to the south-west, Kano and Jigawa States to the south-east, and the Republic of Niger to the north.

Figure 1. Map of Nigeria showing the location of Katsina State

Source: Author's compilation from National Bureau of Statistics administrative maps and Open StreetMap data, 2026.

Figure 2. Map of Katsina State showing Katsina metropolis as the study area

SourceAdapted from OpenStreetMap and administrative boundary data from HDX 2026.

The city has a Köppen BSh (hot semi-arid) climate with a mean annual temperature of 28°C, annual rainfall of approximately 600mm concentrated in a short wet season (June–September), and dry season peaks exceeding 40°C. Katsina was selected as the study site due to its dual character as a city with a significant surviving vernacular built heritage and rapid contemporary residential development making it an ideal context for comparative examination.

A structured questionnaire instrument was developed based on the study objectives and a review of relevant literature. The questionnaire comprised two sections: Section A (for residents, 20 questions) addressing building characteristics, thermal comfort experience, cooling expenditure, and design involvement; and Section B (for builders, 19 questions) addressing material practices, client interactions, climate awareness, and training background. Both sections included closed multiple-choice questions and open-ended items inviting free-text responses. The instrument was piloted with three participants before full distribution to check clarity and response time.

Data collection was conducted through purposive sampling. The questionnaire was distributed via Google Forms shared through WhatsApp networks and administered in-person by co-author Ibrahim Salisu Modoji, who is based in Katsina, at residential areas and active construction sites. A total of 33 completed responses were received. All 33 respondents answered Section A (residents); 27 also completed Section B, indicating professional involvement in construction. Quantitative responses were exported to Google Sheets and analysed using descriptive statistics (frequency counts and percentages). Open-ended responses were subjected to thematic analysis following Braun and Clarke's (2006) six-phase framework: data familiarisation, initial coding, theme development, theme review, theme definition, and final write-up. Participant anonymity is maintained throughout by referencing respondents as Resident 1–33 and Builder 1–27.

Figure 3. Field data collection at an active residential construction site in Katsina metropolis howing sandcrete block construction in progress

Source: Authors, 2024

4. Results and Discussion

A total of 33 questionnaires were completed and returned. The following sub-sections present findings on residential building characteristics, indoor thermal comfort experience, construction practices, and builder knowledge followed by discussion contextualising these findings within the existing literature.

Residential Building Characteristics

The physical profile of respondents' houses reveals a construction landscape dominated by thermally poor materials. As shown in Table 1, 76% of houses are constructed with cement or sandcrete blocks and only 15% with traditional mud brick (tubali). Corrugated metal sheet roofing predominates at 73%, with concrete flat slabs at 18%. The vast majority of houses (73%) are single-storey bungalows. Notably, 85% of households retained some form of internal courtyard or open space 55% with a large courtyard and 30% with a small one suggesting that the spatial memory of the traditional Hausa compound form persists even as materials have changed.

Table 1. Physical characteristics of residential buildings (n=33).

Building Feature	Category	n	%
Wall material	Cement/sandcrete blocks	25	76%
	Mud brick (tubali)	5	15%
	Mixed materials	2	6%
	Unknown	1	3%
Roof type	Corrugated metal sheet	24	73%
	Concrete flat slab	6	18%
	Clay tiles / other	3	9%
Number of floors	Single storey	24	73%
	Two storeys	5	15%
	Three or more	4	12%
Courtyard presence	Yes — large	18	55%
	Yes — small	10	30%
	No courtyard	5	15%

Figure 4. Residential building in Katsina metropolis showing corrugated metal roofing with no insulation and minimal roof overhang a key contributor to indoor heat gain

Source: Authors, 2024

Figure 5. Close-up detail of thin sandcrete block wall and uninsulated corrugated metal roof at a residential building in Katsina, illustrating the absence of thermal barrier between roof and interior

Source: Authors, 2024

Indoor Thermal Comfort and Energy Burden

Table 2 presents residents' thermal comfort perceptions. A combined 60% rated their home as hot or very hot during the dry season, with only 39% reporting comfortable indoor conditions. The kitchen was identified as the hottest space (36%), followed by other bedrooms (27%). Afternoon hours between 2–6pm were the most uncomfortable period for nearly half (48%) of respondents. Indoor conditions were reported as hotter than outside by 54% of respondents, while 24% experienced cooler indoor conditions likely attributable to the partial retention of courtyard forms documented above.

Table 2. Thermal comfort experience (n=33).

Variable	Response	n	%
Indoor temperature	**Comfortable**	**13**	**39%**
	Slightly warm	**9**	**27%**
	Hot — uncomfortable	**10**	**30%**
	Very hot — unbearable	**1**	**3%**
Hottest room	**Kitchen**	**12**	**36%**
	Other bedrooms	**9**	**27%**
	All rooms equally	**5**	**15%**
	Master bedroom / living room	**7**	**21%**
Most uncomfortable time	**Afternoon (2–6pm)**	**16**	**48%**
	Midday (10am–2pm)	**9**	**27%**
	Morning / evening	**8**	**24%**

Indoor vs. outdoor heat	**Slightly hotter inside**	**15**	**45%**
	Cooler inside	**8**	**24%**
	About the same	**7**	**21%**
	Much hotter inside	**3**	**9%**

Mechanical cooling reliance was near-universal: 97% of respondents used fans, air conditioning, or both. Monthly electricity expenditure on cooling was substantial 52% spent ₦5,000–₦15,000, and 30% spent ₦15,000–₦30,000 monthly (Table 3). These figures confirm the financial burden documented by Aliyu et al. (2016) for Northern Nigerian households, where cooling costs consume a disproportionate share of household income, particularly among middle- and lower-income families who cannot afford air conditioning but depend heavily on fans.

Table 3. Mechanical cooling use and monthly electricity expenditure (n=33).

Variable	Response	n	%
Cooling method	**Fans only**	**16**	**48%**
	Both fans and AC	**14**	**42%**
	AC only	**2**	**6%**
	No cooling	**1**	**3%**
Monthly electricity cost	**Less than ₦5,000**	**3**	**9%**
	₦5,000 – ₦15,000	**17**	**52%**
	₦15,000 – ₦30,000	**10**	**30%**
	Over ₦30,000	**3**	**9%**

Open-ended responses reinforced these patterns with personal testimony. Respondents cited excessive afternoon heat, poor cross-ventilation, and heat emitted by walls and roofs in the evening as primary discomforts. One respondent clearly articulated the ventilation design failure:

"The biggest problem is the cross ventilation where air will flow through when there's adjacent and opposite windows but in our case air can only go inside the rooms but cannot pass through them as the windows are on one side" (Resident 23).

A single resident who identified as living in a mud-brick house provided the most direct comparison: "I comfortably live in my house during hot season because it's made from mud bricks" (Resident 33) a statement that encapsulates the thermal advantage of traditional construction documented in the physical literature (Moughtin, 1985; Fathy, 1986).

Construction Practices and Material Choices.

Of the 27 builder respondents, 55% were building contractors, 12% draughtsmen, 9% block masons, and 6% foremen. The majority (58%) had less than five years of experience. Sandcrete blocks of 225mm thickness were the most commonly used wall material (56% of builders), and corrugated zinc sheet dominated roofing at 74% (Table 4). Only one builder

(4%) used mud brick as a primary wall material, confirming near-total displacement of traditional construction techniques from the Katsina residential market a pattern consistent with the broader Northern Nigerian context documented by Abimaje et al. (2013).

Client preference (30%) and low cost (26%) were the leading drivers of material selection, together accounting for more than half of responses. This confirms the pattern identified across West Africa by Vale and Vale (1991) and Aduwo et al. (2013), where economic and aesthetic factors dominate decision-making over thermal performance considerations. One experienced builder captured a systemic structural issue:

"In Katsina what happens is that the foreman was given the choice to design the house and they don't usually care about the ventilation" (Builder 14).

Table 4. Builder material choices and practices (n=27)

Variable	Response	n	% builders
Primary wall material	**Sandcrete blocks 225mm**	**15**	**56%**
	Mixed materials	**8**	**30%**
	Sandcrete blocks 150mm	**3**	**11%**
	Mud brick (tubali)	**1**	**4%**
Roofing type	**Corrugated metal (zinc)**	**20**	**74%**
	Concrete slab	**7**	**26%**
Main reason for material choice	**Client preference**	**8**	**30%**
	Low cost	**7**	**26%**
	Easy to find locally	**6**	**22%**
	Better quality / faster	**6**	**22%**
Roof insulation	**Yes, always / sometimes**	**19**	**70%**
	Rarely / never	**8**	**30%**
Shading devices	**Yes, always / if asked**	**22**	**81%**
	Rarely / never	**5**	**19%**

Figure 6. Builders laying sandcrete blocks at an active residential construction site in Katsina metropolis, illustrating the dominance of cement block construction

Source: Authors, 2024

Figure 7. Mason laying mortar on thin sandcrete block wall, demonstrating the shallow wall thickness typical of contemporary residential construction in Katsina — a key factor in poor thermal performance

Source: Authors, 2024

Builder Knowledge, Client Awareness, and Climate Training

The most significant finding of this study concerns builder perceptions of modern versus traditional building performance. As Table 5 shows, 52% of builders stated that modern houses in Katsina are cooler than traditional mud-brick structures a belief directly contradicted by resident testimony, the physical properties of the materials involved, and the established thermal literature (Onyegiri & Abam, 2015; Dili et al., 2010). Only 15% correctly identified modern houses as much hotter. This widespread misperception among construction professionals including the majority of formally trained contractors represents the most critical finding of this study. Unlike the pattern documented in Lagos or Abuja where architectural awareness of climate-responsive design is growing, the Katsina construction sector appears to operate with a fundamentally incorrect baseline understanding of comparative building thermal performance.

Table 5. Builder knowledge, client behaviour, and climate training (n=27)

Variable	Response	n	% builders
Clients ask about cooling/ventilation	**Always**	**15**	**56%**
	Sometimes	**10**	**37%**
	Never	**2**	**7%**
Clients ask about sun orientation	**Sometimes**	**17**	**63%**
	Always	**7**	**26%**
	Rarely / never	**3**	**11%**
Modern vs. mud-brick houses (heat)	**No, modern are cooler**	**14**	**52%**
	Yes, slightly hotter	**6**	**22%**
	Yes, much hotter	**4**	**15%**
	About same / not sure	**3**	**11%**
Formal construction training	**University / polytechnic**	**15**	**56%**
	Vocational / trade school	**5**	**19%**
	On-the-job / none	**7**	**26%**
Climate-responsive training	**Yes, formal**	**9**	**33%**
	Yes, informal	**8**	**30%**
	Heard of it / never heard	**10**	**37%**
Know prevailing winds	**Yes, and I use it**	**15**	**56%**
	Yes, but do not use it	**6**	**22%**
	No / not sure	**6**	**22%**

Nevertheless, the data also reveal important grounds for optimism. A substantial 56% of builders knew and actively used prevailing wind direction in their work, and 81% expressed willingness to adopt climate-responsive techniques if clients requested them. Builder open responses on improvements (B17) were remarkably convergent with resident suggestions larger windows for cross-ventilation, roof insulation, shading devices, tree planting, and centring buildings within plots to allow airflow. One builder summarised the required changes comprehensively:

"I believe houses in Katsina would be cooler if construction practices placed greater emphasis on proper ventilation, the use of insulated roofing and wall materials, wider roof overhangs for shading, larger and well-positioned windows to improve airflow, and landscaping elements such as trees around buildings" (Builder 9).

This convergence between resident experience and builder understanding of solutions suggests that the primary barrier is not awareness of what needs to change, but the absence of a professional framework, client mandate, and accessible technical guidance to translate this awareness into practice. This has direct implications for the design of interventions: demandside education campaigns and accessible technical guidance for builders are more likely to generate change than top-down regulatory approaches alone in the Katsina context.

5. Conclusions

This study investigated climate-insensitive design practices in contemporary residential buildings in Katsina State, Nigeria, through questionnaire responses from 33 residents and builders. The findings confirm that modern Katsina housing is dominated by sandcrete block walls and corrugated metal roofing materials that perform poorly in the region's hot semi-arid climate driven by client preference for aesthetics and low construction cost. A combined 60% of residents experience hot or uncomfortable indoor conditions; 97% rely on mechanical cooling; and 82% spend between ₦5,000 and ₦30,000 monthly on electricity. The most critical and novel finding is that 52% of builders incorrectly believe modern houses are cooler than traditional mud-brick structures a systemic knowledge gap with direct negative consequences for construction practice in Katsina.

Despite these challenges, 81% of builders expressed willingness to adopt climate-responsive techniques if clients requested them, and open responses from both groups converged on the same solutions: improved cross-ventilation, insulated roofing, shading devices, tree planting, and building orientation. Based on these findings, the following recommendations are proposed: builders should adopt thick wall construction using compressed earth blocks, install roof insulation, orient buildings east–west, and provide external shading on east and west facades; clients and residents should request cross-ventilation design and compound-level shading from trees; policymakers should develop enforceable minimum thermal performance standards for residential construction in Katsina State and integrate climate-responsive design into construction training curricula at institutions including Hassan Usman Katsina Polytechnic.

This study has limitations: the sample of 33 respondents limits statistical generalisability; digital distribution may bias toward younger, more connected participants; and self-reported builder practices may be subject to social desirability bias. Future research should complement these findings with objective thermal measurements comparing traditional and contemporary buildings in Katsina, and comparative studies across Northern Nigerian cities Kano, Sokoto, and Maiduguri to enable region-wide climate-responsive building guidelines.

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