World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(Research Article)

Check for updates

# USER SATISFACTION OF THE THERMAL PERFORMANCE OF STABILIZED EARTH WALLING MATERIALS IN RESIDENTIAL ARCHITECTURE IN BWARI, ABUJA, NIGERIA

Dara David Isah *, Williams Amanyi Idakwoji and Beatrice Chapi Owoicho

Department of Architecture, Faculty of Architecture, Bingham University, Karu, Nigeria.
* Corresponding Author

World Journal of Advanced Research and Reviews, 2026, 31(03), 1357–1369

Publication history: Received on 08 August 2026; revised on 13 September 2026; accepted on 16 September 2026

Article DOI: https://doi.org/10.30574/wjarr.2026.31.3.2390

Copyright © 2026 Author(s) retain the copyright of this article. This article is published under the terms of the Creative Commons Attribution License 4.0

## ABSTRACT

The dominance of cement-sandcrete walling systems in contemporary Nigerian residential construction has produced buildings with high embodied carbon and inadequate passive thermal regulation in hot-humid climates. This study investigates the thermal performance perceptions and community acceptance of improved earth-based walling materials specifically stabilized earth blocks (SEBs), compressed earth blocks (CEBs) and laterite blocks among residents of Bwari Area Council, Federal Capital Territory, Nigeria. A mixed-methods survey of 127 valid respondents was analyzed using descriptive statistics, Likert-scale mean scores and thematic coding. Results indicate high awareness (80.3 %) and strong willingness to reside in earth-walled housing (mean = 4.35/5). Respondents rated the comparative thermal performance of earth/laterite walls versus cement blocks as satisfactory or very satisfactory (80.3 %), while 83.5 % reported frequent reliance on mechanical cooling in their current cement-block dwellings. Preference for stabilized earth or hybrid earth-modern systems reached 80.3 %. Social stigma remains the principal barrier. The findings provide empirical validation for the reintegration of improved earth materials as primary walling systems in climate-responsive housing and inform design strategies that combine high thermal mass, passive cooling features and contemporary aesthetic finishes. Policy implications for local material promotion and artisan capacity building are discussed.

**Keywords:** Stabilized Earth Blocks; Thermal Mass; Climate-Responsive Design; Community Acceptance; Bwari; Tropical Housing; Passive Cooling; Laterite; Compressed Earth Blocks

## 1 INTRODUCTION

Earth has served as a primary building material for millennia across tropical and subtropical regions, valued for its abundance, low embodied energy and high thermal inertia. In the Guinea Savannah belt of Nigeria, including the Bwari Area Council of the Federal Capital Territory, indigenous Gbagyi communities historically constructed dwellings from rammed earth, hand-molded mud, wattle-and-daub and laterite blocks. These vernacular systems exploited the high thermal mass of earthen walls to moderate diurnal temperature swings, producing cooler interiors during the prolonged hot-dry season (March-May) without mechanical intervention (Qurix et al., 2023; Emusa, 2024).

Rapid urbanisation, shifting lifestyle aspirations and the formalisation of the construction sector have, however, displaced traditional earth techniques. Contemporary residential construction in Bwari and wider Abuja relies predominantly on cement-sandcrete hollow blocks. These materials possess relatively low thermal mass and high thermal conductivity, resulting in rapid heat transfer through the building envelope. Occupants consequently experience significant indoor overheating and depend heavily on fans and air-conditioning units, elevating household energy costs and contributing to the carbon footprint of the built environment (Okafor & Awuzie, 2022; Ogunleye et al., 2021). Life-cycle assessment studies of Nigerian building materials confirm that conventional cement-based products carry substantial global warming potential, whereas locally sourced earth materials can significantly reduce the embodied carbon of walls (Haik et al., 2023; Adams et al., 2024).

Parallel advances in earth construction technology particularly the development of stabilized earth bricks (SEBs), compressed earth blocks (CEBs) and improved laterite masonry have demonstrated that mechanical strength, water resistance and durability can be substantially enhanced through modest cement or lime stabilization without sacrificing the material's low-carbon and thermal advantages (Riza et al., 2010; Mora-Ruiz et al., 2025; Asha Sapna & Anbalagan, 2023). Thermal conductivity values for optimized CEBs fall in the range of approximately 0.60-1.20 W/m·K, competitive with or superior to conventional masonry (Turco et al., 2024). Simulation studies further indicate that compressed earth brick walls can reduce heating and cooling energy loads relative to conventional masonry, thereby lowering operational energy demand and associated emissions (Hany et al., 2025).

Despite these technical improvements, adoption in formal Nigerian housing remains limited. Persistent social stigma associating earth construction with poverty, limited technical knowledge among artisans, and the absence of high-quality demonstration projects continue to constrain uptake (Zami & Lee, 2010). There is therefore a clear research need to quantify resident perceptions of thermal performance and acceptability within specific Nigerian peri-urban contexts, and to translate those perceptions into actionable design guidance.

This paper addresses the dual questions of thermal performance perception and community acceptance of improved earth walling systems in Bwari. Drawing on primary survey data collected from 127 residents, the study quantifies awareness, willingness to reside in earth-walled housing, comparative thermal comfort ratings, barriers to acceptance, and preferred design integration strategies. The analysis is situated within the broader literature on bioclimatic design and low-carbon architecture in tropical climates. Findings are intended to inform architects, housing agencies and policy makers seeking to promote sustainable, climate-adapted residential development in Nigeria's peri-urban growth corridors.

## 2 LITERATURE REVIEW

### 2.1 Vernacular Earth Construction and Thermal Mass in Tropical Climates

Vernacular architecture in tropical Africa has long leveraged the thermal capacity of thick earthen walls. High thermal mass materials absorb heat slowly during the day and release it gradually at night, reducing peak indoor temperatures and damping diurnal fluctuations (Stapleton & Meier, 2022; Hema et al., 2020). Empirical studies comparing earth and concrete buildings in hot climates consistently report 2-5 °C cooler interiors in earth structures under similar external conditions (Wakil et al., 2023). Energy savings attributable to thermal mass have been estimated at 20-40 % of cooling loads in passive designs (Lee et al., 2021; Zhang & Wang, 2025). Relative humidity regulation also occurs naturally in earth walls, which absorb and release moisture, contributing to improved indoor comfort (Jiang et al., 2024).

In the specific context of Northern and Central Nigeria, Gbagyi compound layouts characterised by clustered circular or rectangular dwellings around communal courtyards further enhanced microclimatic control through mutual shading and cross-ventilation (Qurix et al., 2023). The progressive abandonment of these systems in favour of free-standing cement-block bungalows has eroded both cultural continuity and passive climate adaptation. Material locality was a core principle of vernacular practice: by sourcing earth on-site, builders achieved low embodied energy, contrasting sharply with imported cement that contributes to higher carbon footprints (Hamard, 2017).

### 2.2 Improved Earth Technologies: SEB, CEB, Rammed Earth and Laterite

Stabilization of earth with small percentages of cement, lime or industrial by-products (fly ash, rice-husk ash) raises compressive strength from the 1-3 MPa range typical of unstabilised adobe to values exceeding 5-7 MPa, and in optimized mixtures up to 24 MPa, sufficient for load-bearing residential construction of two to three storeys (Deshmukh & Yadav, 2025; Mora-Ruiz et al., 2025). Compressed earth blocks produced under controlled hydraulic pressure achieve bulk densities around 1,750 $kg/m^3$ and thermal conductivities in the order of 0.60–0.90 W/m·K (Nshimiyimana et al., 2020; Turco et al., 2024). Unlike fired clay bricks, CEBs require no kiln firing, eliminating the direct correlation between greenhouse gas emissions and coal consumption inherent in conventional brick manufacture (Asha Sapna & Anbalagan, 2023).

Rammed earth (pisé de terre) produces monolithic walls with characteristic horizontal strata and high thermal inertia. Recent experimental work incorporating construction and demolition waste and calcium oxide demonstrated thermal time lags of up to 90 minutes and favourable decrement factors, with significantly lower environmental impact than fired brick or concrete (Fouad et al., 2025). Laterite, abundant across the FCT geological zone, hardens upon exposure (induration) and has historically been cut into masonry blocks. Geotechnical analyses of Nigerian lateritic soils reveal compressive strengths of 2.0-8.0 MPa, adequate for residential load-bearing walls (Oyelami & Van Rooy, 2016). Contemporary Nigerian architectural practice has begun reclaiming laterite as both structural material and refined surface treatment, as exemplified by the laterite Tyrolean technique developed in Lagos (ArchDaily, 2023).

Life-cycle assessments confirm that earth-based wall systems can reduce embodied carbon by up to 90 % relative to cement-intensive alternatives when transport distances are minimised (Dormohamadi et al., 2024; Haik et al., 2023). A narrative review of low-carbon housing in Nigeria has specifically recommended earth-based materials for their effectiveness in reducing carbon emissions while maintaining affordability (Adams et al., 2024).

### 2.3 Bioclimatic Design Principles Relevant to Earth Walling

Bioclimatic design integrates architectural elements with local climate to optimise indoor comfort passively. Key variables include building orientation for solar control, thermal mass utilisation, envelope performance, natural ventilation patterns and solar shading (Ajibola, 2001; Nwalusi et al., 2022). In hot-humid climates such as Abuja's, where temperatures average 25-35 °C with high humidity, orientation that minimises east-west exposures is critical. Cross-ventilation through strategically placed openings, courtyards acting as thermal buffers, and deep overhangs or vegetation that block direct sunlight all complement the thermal mass of earth walls (Chen et al., 2025; Adebamowo & Oluwatosin, 2025). Studies indicate that these combined strategies can reduce peak indoor temperatures by 3-7 °C in tropical housing (Wakil et al., 2023).

### 2.4 Social Acceptability and Barriers to Adoption

Technical performance alone does not guarantee adoption. Zami and Lee (2010) identified social perception, particularly the association of earth construction with poverty and underdevelopment as a critical barrier in low-cost urban housing contexts. Lack of skilled artisans, limited demonstration projects, and the absence of supportive building codes further constrain uptake. Conversely, where high-quality finished examples are visible and where cost and thermal advantages are clearly communicated, willingness to accept earth-based housing rises substantially (Asha Sapna & Anbalagan, 2023). The literature therefore points to the need for concurrent technical improvement, aesthetic modernisation and community engagement if earth materials are to regain a meaningful share of the formal housing market.

### 2.5 Research Gap

While laboratory and simulation studies of earth materials are increasingly available, primary empirical data on resident perceptions of thermal performance and acceptability within specific Nigerian peri-urban contexts remain scarce. This study fills that gap by providing quantified evidence from Bwari residents on awareness, willingness, thermal comfort experience, barriers and preferred design features for improved earth walling systems. The findings are intended to bridge the divide between technical research and community-level decision-making.

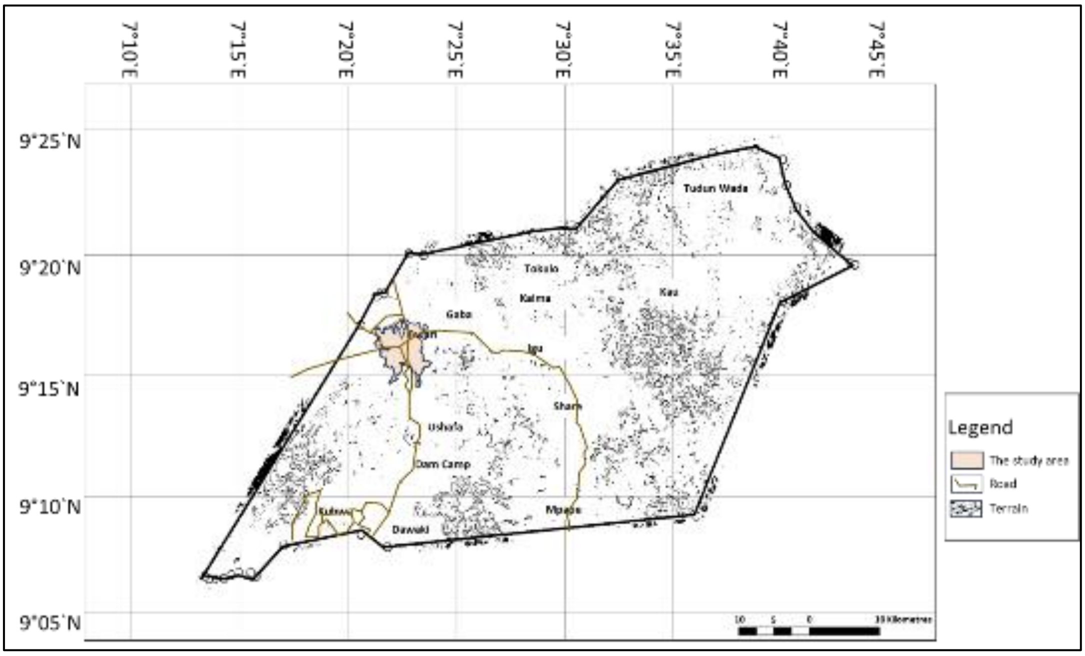
## 3 METHODOLOGY

### 3.1 Research Design

A pragmatic mixed-methods design was adopted, combining quantitative survey data with qualitative thematic analysis of open-ended responses. The approach aligns with architectural research that seeks both measurable indicators of acceptance and nuanced insight into design preferences. The study forms part of a larger design dissertation but is reported here as a self-contained empirical investigation of thermal performance perception and social acceptability. The sequential exploratory logic allowed qualitative insights into vernacular practice to inform the framing of quantitative items, while statistical results provided generalisable indicators of community attitude.

### 3.2 Study Area and Climatic Context

Bwari Area Council lies approximately 25 km north-west of Abuja city centre and constitutes the ancestral homeland of the Gbagyi people. The area experiences a Guinea Savannah climate with a distinct wet season (April-October) and dry season (November-March). Average monthly temperatures range between 23 °C and 35 °C, with peak heat in March-April. The South-West Trade Wind carries moist air from April to October, while the North-East Trade Wind (Harmattan) brings hot, dry Saharan air from November to March. Relative humidity rises sharply during the wet season (up to 31 muggy days in July-August), necessitating both thermal mass and effective natural ventilation strategies. The soil composition of the study area is predominantly clay-loam lateritic, well-suited to on-site production of compressed earth blocks and stabilized laterite masonry.




Source: Author's construct, 2026.

**Figure 1: Map of Bwari Area Council showing the study area location within the Federal Capital Territory, Nigeria.**

### 3.3 Population, Sampling and Sample Size

The target population comprised adult residents (18 years and above) of Bwari with a minimum of six years' residency, together with local builders and professionals familiar with housing materials. Using Taro Yamane's formula for an estimated population of 500,100 and a 5 % margin of error, a target sample of 396 was calculated. In practice, 127 valid questionnaires were returned and analysed an acceptable response rate for field surveys in peri-urban Nigerian settings given time and resource constraints. Stratified random sampling ensured representation across age, occupation and housing tenure categories, while purposive sampling targeted individuals with knowledge of traditional building practices. The final sample included civil servants (24.4 %), farmers (25.2 %), traders (25.2 %), artisans (15.0 %) and unemployed respondents (10.2 %), providing a cross-section of livelihood perspectives relevant to housing affordability and material preference.

### 3.4 Data Collection Instrument and Procedures

The structured questionnaire comprised five sections: (A) demographic profile; (B) traditional walling materials in Bwari indigenous settlements; (C) level of acceptability of earth-based walling materials; (D) capacity of improved earth walls to enhance indoor temperature regulation; and (E) integration of improved earth materials into climate-responsive housing design. Likert-scale items (1–5) and multiple-response questions were employed. Open-ended items invited design suggestions and additional comments. Content validity was established through expert review by three architects; face validity was confirmed via pilot testing with ten participants in Bwari. Reliability was assessed using Cronbach's alpha ($\alpha > 0.70$ for scaled items) and test-retest methods ($r = 0.85$ over two weeks). Data collection was conducted through face-to-face administration in central residential communities of Bwari during the study period.

### 3.5 Data Analysis Methods

Quantitative data were analysed using descriptive statistics (frequencies, percentages, means and standard deviations). Likert-scale means were interpreted as follows: 1.00-1.80 = strongly disagree/very low; 1.81-2.60 = disagree/low; 2.61-3.40 = neutral; 3.41-4.20 = agree/high; 4.21-5.00 = strongly agree/very high. Open-ended responses were coded thematically into categories including stabilisation and modern finishes, passive cooling, cultural integration, artisan training, termite treatment and awareness campaigns. Results are presented in tabular form and discussed against the research objectives and existing literature. Triangulation across quantitative and qualitative data enhanced credibility.

## 4 RESULTS AND ANALYSIS

### 4.1 Demographic Profile of Respondents

Table 1 summarises the demographic characteristics of the 127 valid respondents. The sample was predominantly male (77.2 %) and married (80.3 %). The largest age cohort was 26-35 years (32.3 %), followed by the 36-45 and 46-55 groups (each 25.2 %). The dominance of economically active adults (aged 26-55), representing 82.7 % of respondents, is appropriate to the study's focus on housing demand, material preference and climate-comfort experience. Educational attainment was relatively high: 49.6 % held a degree or HND and a further 18.1 % held postgraduate qualifications, supporting the capacity of respondents to engage meaningfully with questions relating to building materials, thermal comfort and sustainability. Occupationally, civil servants, farmers and traders each constituted approximately one-quarter of the sample. Monthly household income clustered in the ₦101,000-200,000 bracket (39.4 %), with 35.4 % earning below ₦100,000, indicating a substantial segment with limited housing expenditure capacity. More than half of respondents (55.1 %) owned their residence; 52.8 % occupied modern bungalows while 22.8 % still lived in traditional Gbagyi compounds a proportion that provides an important comparative base for assessing lived thermal experience across walling systems.

**Table 1: Demographic Characteristics of Respondents (N = 127)**

| Variable | Category | Freq. | % |
|---|---|---|---|
| Age Group | 18-25 years | 22 | 17.3 |
| | 26-35 years | 41 | 32.3 |
| | 36-45 years | 32 | 25.2 |
| | 46-55 years | 32 | 25.2 |
| Gender | Male | 98 | 77.2 |
| | Female | 29 | 22.8 |
| Marital Status | Married | 102 | 80.3 |
| | Single | 25 | 19.7 |
| Education | Degree/HND | 63 | 49.6 |
| | Postgraduate | 23 | 18.1 |
| | Diploma/NCE | 22 | 17.3 |
| | Secondary/SSCE | 19 | 15.0 |
| Occupation | Farmer | 32 | 25.2 |
| | Trader | 32 | 25.2 |
| | Civil Servant | 31 | 24.4 |
| | Artisan | 19 | 15.0 |
| Housing Tenure | Own | 70 | 55.1 |
| | Rent | 32 | 25.2 |
| Residence Type | Modern Bungalow | 67 | 52.8 |
| | Traditional Gbagyi Compound | 29 | 22.8 |

Source: Field Survey, 2026.

The demographic profile indicates a sample of economically active, relatively educated adults who are current or prospective decision-makers on housing materials. The presence of both modern-bungalow and traditional-compound residents enables comparative insight into lived thermal experience across walling systems. The income distribution further underscores the relevance of affordable, locally sourced materials for a substantial proportion of the population.

### 4.2 Traditional Walling Materials in Bwari Indigenous Settlements

A substantial majority of respondents (80.3 %) reported familiarity with traditional Gbagyi building practices. When asked to identify traditional walling materials, building earth in its various forms rammed earth and hand-molded mud

(24.4 %), earth reinforced with sticks/wattle-and-daub (12.6 %), and composite earth-stone or earth-cement systems emerged as dominant. Collectively, earth-based mentions accounted for approximately 65 % of responses. Local availability and low cost (80.3 %) together with good thermal comfort (72.4 %) were the principal historical reasons for material choice. Cultural significance was acknowledged by 32.3 %, and ease of community construction by 29.9 %. Critically, 85.0 % of respondents had observed the replacement of traditional earth buildings by cement-block construction, confirming the scale of material transition in the area.

**Table 2: Traditional Walling Materials Identified by Respondents**

| Wall Material | Frequency | % of Respondents |
|---|---|---|
| Building Earth (rammed / hand-moulded) | 31 | 24.4 |
| Building Earth reinforced with sticks (wattle & daub) | 16 | 12.6 |
| Rammed Earth + Stone (composite) | 9 | 7.1 |
| Cement sandcrete + Earth (mixed) | 9 | 7.1 |
| Rammed Earth + Building Earth | 8 | 6.3 |
| Stone (laterite/quarried) | 6 | 4.7 |
| Cement sandcrete blocks only | 6 | 4.7 |
| Other combinations | 39 | 30.7 |

Note: Multiple responses permitted. Source: Field Survey, 2026.

**Table 3: Reasons for Historical Choice of Traditional Walling Materials**

| Reason | Frequency | % |
|---|---|---|
| Locally available and cheap | 102 | 80.3 |
| Good thermal comfort | 92 | 72.4 |
| Culturally significant | 41 | 32.3 |
| Easy to construct by community | 38 | 29.9 |
| Sustainable / environmentally friendly | 21 | 16.5 |

Note: Multiple responses permitted. Source: Field Survey, 2026.

These findings corroborate historical accounts that Gbagyi vernacular housing relied primarily on earth walls typically plastered mud on timber frames arranged in concentric compound layouts suited to the local Guinea Savannah climate. The high recognition of thermal comfort as a historical selection criterion (72.4 %) demonstrates that indigenous builders instinctively leveraged earth's high thermal mass for passive climate control, a principle now formally articulated in bioclimatic design theory. The near-universal observation of material replacement (85 %) underlines both the urgency and the relevance of proposing a systematic reintegration of improved earth materials into formal housing design.

### 4.3 Awareness and Acceptability of Improved Earth Materials

**Table 4: Willingness to Reside in an Earth-Walled House**

| Score | Descriptor | Frequency | % |
|---|---|---|---|
| 3 | Neutral | 19 | 15.0 |
| 4 | Willing | 44 | 34.6 |
| 5 | Very Willing | 64 | 50.4 |
| Mean = 4.35 | SD = 0.73 | N = 127 | 100.0 |

Source: Field Survey, 2026. Scale: 1 = Not Willing; 5 = Very Willing.

Awareness of improved earth-based materials (SEB, CEB, stabilised laterite) stood at 80.3 %. Sources of awareness included traditional/family practice, construction sites, media and government projects. Willingness to reside in an earth-walled house yielded a mean score of 4.35 (SD = 0.73) on a five-point scale; 85.0 % of respondents scored 4 or 5 (willing or very willing). No respondent scored 1 or 2, indicating an absence of strong opposition. When asked whether they would recommend improved earth materials for a new residential housing estate in Bwari, 78.0 % answered affirmatively, with only 17.3 % declining.

**Table 5: Acceptability of Earth-Based Walling Materials: Likert-Scale Means (N = 127)**

| Statement | Mean | SD |
|---|---|---|
| Earth materials are environmentally friendly and reduce carbon footprint | 4.41 | 0.66 |
| Improved earth walls are cost-effective compared to cement sandcrete blocks | 4.44 | 0.71 |
| Improved earth walls are durable and resistant to weather if properly stabilised | 4.43 | 0.62 |
| Earth houses still carry a negative image of being 'for the poor only' | 4.44 | 0.65 |
| Improved earth materials overcome problems of traditional mud | 4.21 | 1.10 |
| Earth-based walls look modern and visually pleasing when finished properly | 3.78 | 0.68 |
| Using earth materials respects Gbagyi cultural heritage | 2.99 | 0.71 |

Source: Field Survey, 2026. Scale: 1 = Strongly Disagree; 5 = Strongly Agree.

The highest mean scores were recorded for cost-effectiveness (4.44), environmental friendliness (4.41) and durability under proper stabilisation (4.43). Over 87 % of respondents agreed or strongly agreed that improved earth walls offer a more economical alternative to cement sandcrete, and over 90 % affirmed their environmental benefits. Paradoxically, the statement that earth houses still carry a negative image of being 'for the poor only' also scored 4.44, with 91.4 % agreement, confirming that social stigma remains widely recognised even among respondents who themselves express willingness to live in earth-walled housing. The lowest mean (2.99) concerned the direct linkage of earth materials to Gbagyi cultural heritage, with 80.3 % expressing a neutral or disagreeing position. This may reflect a generational disconnect among younger, more educated respondents who associate traditional materials with underdevelopment rather than cultural identity.

**Table 6: Barriers to Accepting Earth-Based Walling Materials**

| Barrier | Frequency | % of Respondents |
|---|---|---|
| Social stigma (seen as outdated / for the poor) | 23 | 18.1 |
| Fear of durability / erosion | 17 | 13.4 |
| Lack of skilled artisans | 13 | 10.2 |
| None / no major barriers | 9 | 7.1 |
| Higher perceived maintenance | 6 | 4.7 |
| Lack of awareness or examples | 6 | 4.7 |
| Fear of termites / insects | 2 | 1.6 |
| Government policy does not promote it | 2 | 1.6 |
| Other | 49 | 38.6 |

Note: Multiple responses permitted. Source: Field Survey, 2026.

Barriers to acceptance were dominated by social stigma (18.1 % of mentions), fear of durability/erosion (13.4 %) and lack of skilled artisans (10.2 %). Only 1.6 % cited absence of supportive government policy, indicating that the primary constraints are perceptual and skills-based rather than regulatory. Encouragingly, 7.1 % reported no major barriers. The high willingness index (mean 4.35) combined with the 78 % recommendation rate constitutes strong primary evidence that a climate-responsive housing estate utilising improved earth materials is feasible, desirable and contextually appropriate for Bwari, provided that stigma is actively addressed through design quality and demonstration.

### 4.4 Capacity of Improved Earth Walls to Enhance Indoor Temperature Regulation

Self-reported indoor thermal comfort during the hot/dry season yielded a mean of 4.07 (SD = 0.71). However, only 22.8 % rated their comfort as ‘very comfortable’, while 19.7 % indicated some degree of overheating. Critically, 50.4 % of respondents experienced overheating ‘sometimes’ or ‘often’, and not a single respondent reported never experiencing overheating. Cement sandcrete blocks constituted the primary walling material of 43.3 % of homes; traditional earth and laterite together accounted for 37.0 %. Only 2.4 % currently occupied stabilised SEB/CEB dwellings, underscoring the under-representation of improved earth systems in the existing stock despite their documented technical merits.

**Table 7: Current Primary Walling Material of Respondents’ Homes**

| Wall Material | Frequency | % |
|---|---|---|
| Cement sandcrete blocks | 55 | 43.3 |
| Mud / traditional earth | 29 | 22.8 |
| Laterite blocks | 18 | 14.2 |
| Stabilised earth (SEB/CEB) | 3 | 2.4 |
| Undecided / Mixed | 22 | 17.3 |

Source: Field Survey, 2026.

**Table 8: Thermal Comfort and Performance Perceptions (N = 127)**

| Statement / Indicator | Mean / % | SD / n |
|---|---|---|
| Current indoor thermal comfort (hot/dry season) | 4.07 | 0.71 |
| Earth/laterite walls thermal performance vs cement (Satisfactory + Very Satisfactory) | 80.3% | 102 |
| Passive temperature regulation is important when choosing wall materials | 4.50 | 0.63 |
| Earth-based walls provide excellent thermal mass and keep houses cooler | 4.57 | 0.67 |
| Current home requires frequent use of fans or AC due to poor wall insulation | 4.17 | 0.69 |
| Would choose improved earth walls specifically for better thermal comfort | 4.57 | 0.67 |

Source: Field Survey, 2026.

Comparative thermal performance ratings were strongly favourable toward earth and laterite: 80.3 % rated them satisfactory or very satisfactory relative to cement sandcrete, with no respondent reporting dissatisfaction. The statements ‘Earth-based walls provide excellent thermal mass’ and ‘I would choose improved earth walls specifically for better thermal comfort’ both recorded means of 4.57 (SD = 0.67), with combined agreement of 89.7 %. The importance of passive temperature regulation when choosing wall materials scored a mean of 4.50, affirmed by 92.9 % of respondents. Simultaneously, 83.5 % agreed that their current homes require frequent mechanical cooling because of poor wall insulation (mean 4.17). Those who indicated ‘rare overheating’ (17.3 %) corresponded largely with residents of traditional earth-walled or laterite-block homes, providing qualitative evidence that earth-based wall materials perform better in passive thermal regulation than their cement counterparts.

These data constitute robust community-level validation of the scientifically documented thermal advantages of earthen construction and quantify the passive thermal deficiency of the existing cement-block stock. The convergence of high thermal-mass perception scores with high willingness to choose earth specifically for comfort provides a strong empirical foundation for design recommendations that prioritise improved earth walling.

### 4.5 Preferred Walling Materials and Design Integration Features

When asked to nominate a preferred walling material for a proposed climate-responsive housing estate in Bwari, 50.4 % selected improved stabilised earth blocks (SEB/CEB/laterite) and a further 29.9 % preferred a hybrid earth-plus-modern-finishes system yielding a combined preference of 80.3 %. Only 17.3 % preferred conventional cement blocks, and a mere 2.4 % preferred traditional mud/adobe. The strong preference for the hybrid system is architecturally instructive: it suggests that many residents are willing to embrace earth materials if these are combined with contemporary finishes (plaster render, paint, tiled floors) that signal quality and permanence.

**Table 9: Preferred Walling Material for Proposed Climate-Responsive Housing Estate**

| Preferred Material | Frequency | % |
|---|---|---|
| Improved stabilised earth blocks (SEB/CEB/laterite) | 64 | 50.4 |
| Hybrid (earth + modern finishes) | 38 | 29.9 |
| Conventional cement blocks | 22 | 17.3 |
| Traditional mud / adobe | 3 | 2.4 |

Source: Field Survey, 2026.

**Table 10: Importance Ratings for Design Features in the Proposed Housing Estate**

| Design Feature | Mean | SD | % Scoring 4–5 |
|---|---|---|---|
| Passive cooling (courtyards, cross-ventilation, shading) | 4.93 | 0.26 | 100.0 |
| Sustainability features (landscaping, rainwater harvesting) | 4.71 | 0.46 | 99.2 |
| Affordable construction via traditional materials | 4.71 | 0.46 | 100.0 |
| Cultural elements (compound layout, granary-inspired forms) | 4.70 | 0.48 | 99.2 |
| Use of locally available earth materials | 4.65 | 0.48 | 100.0 |
| Building orientation responding to sun path and winds | 4.60 | 0.62 | 93.0 |

Source: Field Survey, 2026. Scale: 1 = Not Important; 5 = Extremely Important.

Importance ratings for design features were uniformly high (means 4.60-4.93). Passive cooling strategies scored the maximum possible mean of 4.93, with 100 % of respondents rating them 4 or 5 confirming that passive climate control is not merely a technical aspiration but an absolute design priority for Bwari residents. Local earth materials, affordability, cultural elements and sustainability features all scored above 4.65. Open-ended responses reinforced these quantitative findings. Respondents repeatedly emphasised the need for proper stabilisation combined with modern plaster or paint finishes, the incorporation of courtyards and large overhangs, retention of Gbagyi compound spatial logic, training of local artisans, and termite treatment plus drainage detailing. Awareness campaigns and pilot demonstration projects were frequently recommended as means of building public confidence.

## 5 DISCUSSION

### 5.1 Traditional Continuity and the Scale of Material Transition

The survey confirms that earth-based construction encompassing rammed earth, hand-moulded mud, wattle and daub, and laterite blocks was the predominant walling technology in the traditional Gbagyi settlements of Bwari. That 80.3 % of respondents remain familiar with traditional building practices despite the widespread transition suggests that cultural memory of earth construction is still accessible and can be mobilized as a design resource. The 85 % observation rate of replacement by cement-block construction documents a rapid material shift that has eroded both cultural continuity and passive climate adaptation. Retention of this cultural memory provides a foundation upon which improved earth systems can be reintroduced without appearing entirely alien to the community.

### 5.2 Acceptability: The Paradox of Willingness and Stigma

The study's most significant acceptability finding is that 85.0 % of respondents expressed willingness to reside in an earth-walled house (mean = 4.35) and 78.0 % would recommend improved earth materials for a new Bwari housing estate. These figures substantially exceed what might be anticipated given the documented persistence of social stigma, and suggest that when improved earth materials are framed as technically advanced, cost-effective and aesthetically modern, community resistance diminishes substantially. The persistently negative social image of earth housing (mean = 4.44 for the 'for the poor' perception) remains the most intractable barrier and must be strategically countered through the architectural quality and finish of any proposed estate. The relatively low mean on cultural-heritage linkage (2.99) further implies that framing earth materials primarily as modern, technical and climate-smart solutions may be more persuasive than appeals to tradition alone, at least among the younger and more educated segments of the population. Architectural design quality, contemporary finishes and visible demonstration projects therefore become critical levers for converting latent willingness into actual adoption.

### 5.3 Thermal Performance: Community Validation of Scientific Evidence

The thermal performance findings constitute the strongest empirical basis for the integration argument. A mean willingness score of 4.57 for choosing earth walls for thermal comfort, combined with the overwhelming satisfaction ratings (80.3 %) for the comparative thermal performance of earth versus cement walls, provides community-level validation for the scientifically documented thermal mass advantages of earthen construction (Hema et al., 2020; Wakil et al., 2023; Turco et al., 2024). The finding that 83.5 % of respondents rely on fans or air-conditioning due to inadequate wall insulation quantifies the passive thermal deficiency of Bwari's current cement-block housing stock and the associated energy and cost burden. Those currently living in earth or laterite homes reported rarer overheating, reinforcing the perceptual consensus with lived experience. These results align with simulation studies showing that CEB walls can reduce energy loads related to heating and cooling compared with conventional masonry (Hany et al., 2025) and with experimental work demonstrating favourable thermal time lags in stabilised earth walls (Fouad et al., 2025).

### 5.4 Design Integration: A Community Brief for Practice

The design integration data present a clear and consistent community brief. The highest-importance feature passive cooling strategies (mean = 4.93) aligns directly with the bioclimatic design principles central to climate-responsive architecture. The near-equal valuation of local materials, affordability, cultural elements, sustainability and building orientation confirms that any proposed estate must pursue an integrated design approach in which no single dimension is sacrificed for another. The preference for hybrid earth-modern systems (29.9 %) alongside stabilised earth blocks (50.4 %) provides a pragmatic design direction: the estate should offer a range of earth-based walling options, from pure SEB/CEB systems to earth-plaster hybrid approaches, to accommodate the spectrum of resident preferences. Open-ended thematic analysis further specifies the need for proper stabilisation, modern finishes, courtyards, cross-ventilation, large overhangs, Gbagyi-inspired compound layouts, artisan training, termite treatment and drainage detailing. These requirements map directly onto established bioclimatic strategies and contemporary earth construction best practice.

### 5.5 Implications for Policy, Practice and Capacity Building

Findings support targeted policy interventions: inclusion of stabilised earth standards in local building codes; incentives or demonstration projects by FCT housing agencies; vocational training in CEB production and earth masonry; and public awareness campaigns that emphasise thermal comfort, cost and environmental benefits rather than solely cultural heritage. Architects and developers should treat earth materials not as a low-cost residual option but as a high-performance, climate-adapted walling system capable of meeting contemporary aesthetic expectations when properly detailed and finished. The low preference for pure traditional mud/adobe (2.4 %) confirms that unimproved vernacular techniques are no longer considered adequate; improvement and modernisation are essential. Capacity building for local artisans is particularly urgent, given that lack of skilled labour was cited as a barrier by 10.2 % of respondents and that quality control will determine whether stabilised earth systems realise their technical potential in practice.

### 5.6 Limitations

Several limitations should be acknowledged. The achieved sample of 127, while adequate for descriptive analysis, falls short of the calculated Yamane target of 396 and may limit generalisability. Self-reported thermal comfort is subject to perceptual bias and does not substitute for instrumented monitoring. Seasonal variation in thermal experience could not be fully captured within the survey window. Laboratory testing of local soil stabilisation mixes was beyond the scope of the perceptual study. Future research should complement perceptual data with long-term thermal monitoring of occupied earth-walled and cement-block dwellings under identical climatic conditions, and should evaluate the durability and maintenance performance of stabilised earth systems in the Bwari microclimate.

### 5.7 Comparative Analysis with Regional Studies

The findings from Bwari align with and extend regional evidence on earth construction acceptance. Studies in North-western Nigeria have similarly documented the energy-efficiency potential of CEBs in hot-dry climates (Maimagani et al., 2023), while research in other West African contexts has highlighted the dual challenge of technical optimisation and social perception (Zami & Lee, 2010). What distinguishes the present study is the simultaneous quantification of thermal performance perception, willingness indices and design feature priorities within a single peri-urban sample. The mean willingness score of 4.35 and the 80.3 % preference for stabilised or hybrid earth systems provide stronger community endorsement than many earlier studies that reported residual scepticism. This may reflect growing environmental awareness, rising energy costs associated with mechanical cooling, and the increasing visibility of improved earth technologies in Nigerian professional discourse.

Furthermore, the near-universal prioritisation of passive cooling strategies (mean 4.93) suggests that Bwari residents evaluate walling materials not in isolation but as components of an integrated climate-responsive package. This integrated valuation has important implications for design practice: architects cannot simply substitute CEB for sandcrete within conventional plan forms and expect community endorsement. Courtyards, cross-ventilation, orientation and shading must be co-designed with the material system. The hybrid preference (29.9 %) further indicates that surface treatment and formal language matter as much as structural composition. In this respect, the laterite Tyrolean and exposed CSEB aesthetic strategies emerging in Lagos and other Nigerian centres offer transferable precedents that can elevate the perceived status of earth construction.

### 5.8 Synthesis of Analytical Findings

Synthesising the four analytical strands traditional materials, acceptability, thermal performance and design preferences yields a coherent picture. Traditional earth construction in Bwari was valued for availability, cost and thermal comfort; its displacement by cement has produced dwellings that residents themselves rate as thermally inadequate. Improved earth systems are widely known, strongly preferred for new construction, and specifically valued for thermal mass. Barriers are primarily perceptual (stigma) and practical (skills), not fundamental rejection. Design priorities converge on passive cooling, local materials, affordability and cultural responsiveness. The analytical implication is that technical substitution of walling material, while necessary, is insufficient; it must be embedded within a broader design framework that addresses aesthetics, spatial tradition, climate strategy and capacity building simultaneously. This multi-dimensional requirement distinguishes successful climate-responsive earth architecture from mere material substitution.

The quantitative pattern is consistent across tables: high means on thermal and environmental attributes (4.41-4.57), high means on design feature importance (4.60-4.93), high willingness (4.35), yet persistent stigma recognition (4.44) and low cultural-heritage linkage (2.99). This pattern supports a strategic communication approach that leads with thermal comfort, cost and modernity rather than heritage nostalgia, while still incorporating spatial and formal references to Gbagyi compound tradition as design enrichment rather than primary justification.

In practical terms, the analytical results support a phased implementation strategy. Phase one would prioritise demonstration units that showcase stabilised earth or hybrid wall systems with high-quality finishes, deep overhangs and courtyard configurations, allowing residents to experience thermal performance first-hand. Phase two would expand artisan training programmes focused on CEB production, stabilisation ratios suitable for local lateritic soils, and construction detailing for moisture and termite resistance. Phase three would integrate improved earth standards into FCT development control guidelines and housing agency procurement specifications. Such a sequenced approach addresses the stigma barrier through visible quality, the skills barrier through training, and the institutional barrier through formal recognition directly responding to the hierarchy of constraints identified in the survey data.

Finally, the study contributes methodologically by demonstrating that community perception surveys, when carefully structured around thermal comfort, acceptability and design preference dimensions, can yield actionable design briefs that complement laboratory and simulation research. The high internal consistency of importance ratings (all design features scoring above 4.60) and the clear preference hierarchy for walling materials provide designers with quantifiable guidance that is often missing from purely technical studies. Future work that couples such perceptual instruments with post-occupancy thermal monitoring would further strengthen the evidence base for climate-responsive earth architecture in tropical Africa.

## 6 CONCLUSION

This study has demonstrated that residents of Bwari possess high awareness of improved earth-based walling materials, express strong willingness to occupy earth-walled housing, and recognise the superior thermal performance of earth and laterite relative to cement sandcrete. Social stigma remains the principal barrier, yet it coexists with latent demand that can be unlocked through high-quality architectural design, contemporary finishes, demonstration projects and artisan training. Passive cooling strategies, local material use, affordability and cultural responsiveness emerge as non-negotiable design priorities.

The empirical evidence presented here validates the technical literature on thermal mass and low-carbon construction while supplying context-specific guidance for architects, housing agencies and policy makers operating in Nigeria's tropical peri-urban zones. Improved earth walling systems when stabilised, properly detailed and aesthetically finished offer a viable, socially acceptable and thermally superior alternative to the dominant cement-sandcrete paradigm. Their systematic reintegration into residential design constitutes a practical pathway toward climate-responsive, low-carbon and culturally grounded housing in Bwari and comparable tropical contexts.

Future research should prioritise instrumented comparative thermal monitoring, long-term durability assessment of locally stabilised earth systems, and post-occupancy evaluation of demonstration projects. Policy makers are encouraged to incorporate stabilised earth standards into FCT development control regulations and to support pilot housing schemes that showcase the thermal, economic and aesthetic potential of improved earth materials.

## STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

### *Acknowledgments*

The authors sincerely appreciate the contributions of their fellow colleagues for their valuable support and constructive feedback throughout the development and refinement of this manuscript. The authors also acknowledge the lecturers in the Department of Architecture, Bingham University, for their academic guidance, insightful comments, and constructive feedback, which contributed to the improvement of this work.

### *Funding Source*

The funding was done by Dara David Isah, Transaction ID: 4BW540027J436060J through the paypal payment gateway.

### *Disclosure of conflict of interest*

The authors declare no conflicts of interest regarding this manuscript.

## REFERENCES

[1] Adams, W., Roberts, E., & Turner, J. (2024). Assessing sustainable building practices for carbon reduction in residential housing: A Nigerian perspective. Ayden International Journal of Environmental Sciences and Allied Research, 12(3).

[2] Adebamowo, O., & Oluwatosin, O. (2025). Bioclimatic strategies for tropical housing: Lessons from Nigeria. Journal of Sustainable Architecture, 18(2), 45–61.

[3] Ajibola, M. (2001). Climate-responsive architecture in Nigeria: Principles and practice. Lagos University Press.

[4] ArchDaily. (2023, July 21). Exploring local material in contemporary architecture: PWDC transforms building surfaces in Nigeria. https://www.archdaily.com/1004325

[5] Asha Sapna, A. P., & Anbalagan, C. (2023). Sustainable eco-friendly building material—a review towards compressed stabilized earth blocks and fire burnt clay bricks. IOP Conference Series: Earth and Environmental Science, 1210(1), 012023.

[6] Chen, S., Feng, J., Xue, F., & Hu, Q. (2025). Climate-responsive design for sustainable housing: Thermal comfort, spatial configuration, and environmental satisfaction in subtropical void decks. Buildings, 15(21), 3846.

[7] Deshmukh, M., & Yadav, M. (2025). Optimizing thermal efficiency of building envelopes with sustainable composite materials. Buildings, 15(2), 230.

[8] Dormohamadi, M., Rahimnia, R., & Bunster, V. (2024). Life cycle assessment and life cycle cost analysis of different walling materials with an environmental approach. The International Journal of Life Cycle Assessment, 29(3), 355–379.

[9] Emusa, H. (2024). Commonalities in the traditional architecture of Northern and Southern Nigeria: A comparative analysis.

[10] Fouad, W., Youssf, O., Allam, R. Y. M., & Tahwia, A. M. (2025). Thermal insulation and mechanical performance of sustainable rammed earth walls incorporating construction and demolition waste and calcium oxide. Scientific Reports, 15, Article 30472.

[11] Haik, R., Meir, I. A., & Peled, A. (2023). Lime hemp concrete with unfired binders vs. conventional building materials: A comparative assessment of energy requirements and $CO_2$ emissions. Energies, 16(2), 708.

[12] Hamard, E. (2017). Rediscovering of vernacular adaptative construction strategies for sustainable modern building: Application to cob and rammed earth (Doctoral dissertation). Université de Lyon.

[13] Hany, E., Fouad, N., & Mahmoud, S. (2025). Simulating the thermal behavior of compressed earth brick walls. International Journal of Concrete Structures and Materials, 19, 27.

[14] Hema, C., Messan, A., Lawane, A., & Van Moeseke, G. (2020). Impact of the design of walls made of compressed earth blocks on the thermal comfort of housing in hot climate. Buildings, 10(9), 157.

[15] Jiang, B., Lu, R., Jiang, M., Wang, L., Chun, L., & Wan, L. (2024). Experimental study on thermal and humidity properties of modified rammed earth buildings in winter. Building and Environment, 258, 111583.

[16] Lee, C., Kim, J., & Park, S. (2021). Passive cooling strategies in earth-based tropical housing. Journal of Building Performance, 14(3), 210–226.

[17] Mora-Ruiz, V., Soto-Paz, J., Attia, S., & Mejía-Parada, C. (2025). Sustainable earthen construction: A meta-analytical review of environmental, mechanical, and thermal performance. Buildings, 15(6), 918.

[18] Nshimiyimana, P., Messan, A., Zhao, Z., & Courard, L. (2020). Chemico-microstructural changes in earthen building materials containing calcium carbide residue and rice husk ash. Construction and Building Materials, 216, 622–631.

[19] Nwalusi, T., Obi, I., Chendo, A., & Okeke, C. (2022). Application of vernacular design for climate adaptation in Nigerian housing. International Journal of Sustainable Built Environment, 11(1), 33–50.

[20] Ogunleye, A. O., Adekunle, A., & Ayo, C. K. (2021). Assessment of indoor thermal comfort in Nigerian residential buildings. Journal of Building Performance, 12(1), 30–40.

[21] Okafor, M. U., & Awuzie, B. O. (2022). Evaluation of indoor thermal comfort conditions of traditional and modern buildings in warm-humid climates. Sustainability, 14(19), 12138.

[22] Oyelami, C. A., & Van Rooy, J. L. (2016). Geotechnical characterisation of lateritic soils from south-western Nigeria as materials for cost-effective and energy-efficient building bricks. Environmental Earth Sciences, 75, 1–14.

[23] Qurix, W. B., Emusa, H., & Martins, R. (2023). Response of Gbagyi traditional building pattern to modern architecture in Abuja, Nigeria. African Journal of Architecture, 12(1), 75–94.

[24] Riza, F. V., Rahman, I. A., & Zaidi, A. M. A. (2010). A brief review of compressed stabilized earth brick (CSEB). 2010 International Conference on Science and Social Research (CSSR 2010), 999–1004.

[25] Stapleton, S. R., & Meier, B. K. (2022). Science education for and as resiliency through indoor agriculture. Journal of Research in Science Teaching, 59(2), 169–194.

[26] Turco, C., Abedi, M., Teixeira, E., & Mateus, R. (2024). Thermophysical properties of compressed earth blocks incorporating natural materials. Energies, 17(9), 2070.

[27] Wakil, K., El Mghari, A., Idrissi Kaitouni, A., & El Amraoui, M. (2023). Thermal comfort analysis of earth and concrete residential buildings in tropical regions. Energy and Buildings, 293, 112941.

[28] Zami, M. S., & Lee, A. (2010). Economic benefits of contemporary earth construction in low-cost urban housing—state-of-the-art review. Journal of Building Appraisal, 5(3), 259–271.

[29] Zhang, L., & Wang, H. (2025). Passive design performance of earth buildings in hot-humid climates. Sustainable Cities and Society, 101, 104–119.