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Impact of Climate Change on Sustainable Architectural Practices in North Eastern Nigeria: Passive Cooling, Flood-Resistant Structures, and Community-Based Adaptation in Borno and Adamawa States

[1]Samaila, Umar, [2]Hamza Abubakar, Dadum

[1,2]Department of Architecture, Gombe State University, Nigeria
Corresponding Author's E-mail: arcsamailaumar@gsu.edu.ng, https://orcid.org/0009-0008-2871-137X

***Abstract* - Climate change poses existential dangers to communities in North Eastern Nigeria, where rising temperatures and increasingly unpredictable rains make conventional housing unsuitable and, in some circumstances, untenable. This research investigates climatic vulnerability and sustainable building methods in Borno and Adamawa states, which are dealing with humanitarian crises and acute energy poverty. Nigeria has a serious energy access deficit: nearly 40% of the population, or 90 million people, lacks grid connectivity, one of the greatest gaps in Sub-Saharan Africa. The analysis of forecasted climate data, passive cooling techniques, flood-resistant building, and community-based adaptation reveals both innovations and implementation challenges. The findings show that anticipated temperature rises of up to 5.2°C by 2100 need climate-responsive design, including solar shading, thermal mass insulation, and passive ventilation. A thorough study of passive cooling solutions in African environments reveals that integrated approaches result in 3-5°C reductions in interior temperature and 20-60% reductions in cooling energy consumption. Concurrently, recurring flooding necessitates structural changes such as flood-resistant materials and green infrastructure. The paper describes promising community-driven interventions compressed stabilised earth block construction, the Muna Type Transitional Shelter, and the Birkaroonlatrine, which received 98% user acceptance while identifying policy gaps, financial constraints, and knowledge deficits as primary scaling barriers. The recently announced Minimum Energy Performance Standards (MEPS) for air conditioners, which are set to be implemented by 2026, constitute an important legislative lever for decreasing cooling-related emissions. Women and girls endure disproportionate climate and energy responsibilities, yet their involvement in solution creation is restricted. The study indicates that effective adaptation necessitates integrated methods that include technological innovation, strong policy frameworks, meaningful community engagement (including gender-responsive design), and alignment with energy access policies. With 40% of Nigerians without grid connection and the national system failing nine times in 2024 alone, architectural and energy transformations must occur concurrently.**

Keywords: climate change adaptation, passive cooling, flood-resistant construction, sustainable architecture, North Eastern Nigeria, energy poverty.

I. INTRODUCTION

Climate change is no longer a distant future in the Sahel; it is a contemporary reality that is changing the built environment. In North Eastern Nigeria, this manifests as two intersecting crises: average temperatures that have already risen significantly since pre-industrial levels, and rainfall intensification that, in September 2024, submerged 70% of Maiduguri, the capital of Borno State, displacing 400,000 people (European Commission, 2024). These are not anomalies but signals of a trajectory: under high-emissions scenarios, temperatures in the region could increase by 4.1°C to 5.2°C by 2100 (Arias, *et al.*, 2021; Pörtner, *et al.*, 2022; Alegbe *et al.*, 2025). Extreme precipitation events are projected to become more frequent and intense (Klutse, *et al. et al.*, 2024).

The impacts on the built environment are substantial. Housing developed without regard for future climates will become more uninhabitable. In Borno and Adamawa states, where an estimated 2.2 million people are still displaced by fighting (Mercy Corps, 2024), the majority of accommodation is made up of emergency constructions with no thermal insulation and a significant risk of flooding. This dilemma extends beyond physical structures to the energy systems that keep buildings operational. Nigeria has a stunning energy access deficit: over 40% of the population, or 90 million people, do not have access to grid power, making it the world's biggest such population. Nigeria is one of nine "Critical 9" nations, with 114.9 million people 53 percent of

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the population facing severe climate risk due to the convergence of excessive heat, poverty, and insufficient cooling access (Sustainable Energy for All, 2023). With rural electrification rates far below 30%, the majority of people in North Eastern Nigeria are unable to operate fans, air conditioners, or basic lights, making passive design more than just an efficiency measure, but a survival need.

The vulnerability of the national grid exacerbates the problem. In 2024, the grid saw nine system failures, a pattern that extended into 2026 with breakdowns in January and February exposing ongoing system incoherence: poor observability, protection discipline, and revenue collection. Only 46.57% of registered customers are metered, which means that more than half of them cannot be appropriately paid, jeopardising maintenance and stability investments. When the grid fails, Nigerians rely on diesel and petrol generators for around 40% of their electrical needs. This dependency has tremendous costs: companies lose an estimated $26 billion each year, while generator emissions harm air quality and contribute millions of tonnes of CO^2, comparable to Nigeria's carbon footprint.

For displaced people, survival depends on convergence. Johnson, (2025), Women and girls endure disproportionate burdens: they make up the bulk of fuelwood collectors, exposing them to violence and driving deforestation, and they are main carers in households with indoor air pollution, which kills an estimated 98,000 people in Nigeria each year (WHO, 2022). The North poses Nigeria's most complicated energy dilemma, with states such as Borno, Yobe, and Adamawa dealing with conflict, deserts, and extreme poverty.

Despite these serious risks, large information gaps prevent action. A comprehensive evaluation indicates a gap: while passive cooling has been modelled in Abuja (Adaji, 2017; Abdulkareem and Al-Maiyah, 2025) and flood-resistant measures reported in Lagos (Ilesanmi *et al.*, 2025), no study has rigorously evaluated how these approaches apply to the unique circumstances of Borno and Adamawa. Protracted displacement, institutional fragility, and the erosion of Hausa building traditions thick mud walls, shaded verandas (zaure), and courtyard configurations (tsakargida) that once mediated thermal comfort without mechanical systems have all contributed to these conditions (Moughtin, 1985; Sa'ad, 1981).

Simulations, rather than post-occupancy evaluation, determine the success of passive cooling in conflict-affected environments. A recent analysis discovered a "persistent gap between designer aspirations and user comfort," indicating the need for climate-based recommendations. Flood-resistant building research has mostly concentrated on permanent urban housing, rather than the transitory and incremental shelters commonly utilised in humanitarian response. According to Ndububa, & Mukaddas, (2016), 76% of studied mud dwellings in Bauchi had wall collapses, with compressive strengths much lower than the Nigerian norm of 2.5N/mm^2 for sandcrete blocks (Federal Ministry of Power, 2024).

Adaptation is often studied apart from the energy availability dilemma. However, a passively cooled structure is uninhabitable at night without lights, and a clinic cannot keep vaccinations without reliable power. While the National Energy Compact and the World Bank's $750 million DARES initiative seek to increase renewables by 2030, architectural practice lacks a unified framework to meet these goals.

This study addresses these gaps using three interrelated lines of inquiry:

1. Which passive cooling systems are technically viable and socially acceptable in Borno and Adamawa? How do they relate with traditional Hausa traditions and the 2025 energy performance standards?
2. Flood-Resistant Construction: What structural techniques have been used in humanitarian initiatives, and how did they function during previous floods?
3. Community-Based Adaptation: How do displaced populations, particularly women, contribute to planning and sustaining their built environment? What role might energy access play in shelter programs?

The paper provides evidence-based recommendations for policy and practice, based on a systematic synthesis of peer-reviewed research ($34), humanitarian evaluations ($12), and design innovations, such as the Muna Type Transitional Shelter and hybrid microgrid models from villages like Kabuiri, where solar systems achieve electricity costs of $0.093/kWh (Lewis et al., 2024).

II. LITERATURE REVIEW

2.1 Climate Projections and Building Vulnerability in Nigeria

Recent climate modelling presents a harsh assessment of Nigeria's warming trend, with far-reaching consequences for developing habitability. According to the IPCC's Sixth Assessment Report, under high-emissions scenarios (SSP5-8.5), West African temperatures would increase by 3°C to 6°C by 2100. Because of its geographic position and current climatic circumstances, the Sahel, especially North Eastern Nigeria, is facing the most intense warming (Arias, *et al.*, 2021). Alegbe *et al.* (2025) predict an average rise of 5.2°C by the end of the century. This kind of heat threatens the longevity of existing building stock, particularly homes built

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without climatic considerations or access to mechanical cooling.

Nigeria's energy infrastructure is completely insufficient to meet escalating demand. While the country has a paper capacity of 12,000-13,500 MW (Diop, 2025), actual delivery in 2023 was approximately 4,500 MW for a population of more than 200 million. This leads in an annual per capita usage of only 140-150 kWh, which is significantly lower than Bangladesh (600+ kWh) and the world average of 3,200 kWh (World Bank, 2024). Nigeria's renewable energy capacity of 3,079 MW is much lower than that of South Africa (13,516 MW) and Egypt (7,752 MW). Ethiopia just installed 6,000 MW in a single expansion, demonstrating the scope of Nigeria's standstill.

The vulnerability of the national grid exacerbates these shortcomings. In 2024, NERC (Nigerian Electricity Regulatory Commission, 2024), reported nine system failures: five partial and four entire. As of late 2024, just 46.57% of registered users were metered, jeopardising the cash streams required for upkeep. Analysts describe the industry as having "system incoherence," which is a mix of inadequate observability, protection discipline, and money-flow discipline. As a result, Nigeria has a substantial cooling access gap, with 114.9 million people at risk owing to the combination of intense heat and energy poverty (Sustainable Energy for All, 2023).

2.2 Passive Cooling: Principles and Regional Evidence

Passive cooling, or maintaining pleasant temperatures without the use of mechanical equipment, provides a means of survival in the absence of grid energy (Abdulkareem and Al-Maiyah, 2025). Solar shading, thermal mass utilisation, and natural ventilation are among the most important measures (Geissler *et al.*, 2018). Nigeria's 2017 Building Energy Efficiency Code (BEEC) requires a maximum window-to-wall ratio of 20% without shade and specifies roof insulation criteria.

A thorough evaluation of current African architecture indicated that multi-strategy techniques cut interior temperatures from 3°C to 5°C and cooling demand from 20-60% (Eyiah-Botwe, 2026). Historical Hausa architectural traditions give a model for flexibility through four fundamental elements:

1. Tubali (sun-dried mud bricks) has a high thermal mass that helps moderate temperature fluctuations throughout the day.
2. Zaure (Entrance Hall/Veranda) is a shaded buffer zone.
3. Tsakar Gida (Courtyard): Improves air circulation via the stack effect.
4. Deep Window Reveals: Reduce direct sunlight gain.

Empirical research backs up these strategies. In Abuja, Adaji (2017) discovered that combining roof/wall insulation with external shade lowered interior maximums by almost 5°C. Low-income households saved 45% of the national minimum wage. Nature-based solutions, such as green walls, have produced 2.3°C reductions in Lagos slums (Akinwolemiwa *et al.* 2018). While the federal government adopted new Minimum Energy Performance Standards (MEPS) for air conditioners in 2025, implementation has been patchy in Borno and Adamawa's informal sectors.

2.3 Flood Risk and Building Resilience

Flooding is a serious concern, as seen by the 2024 Maiduguri disaster, in which 70% of the city was drowned. Ilesanmi *et al.* (2025) divide resilience into four categories: structural adaptations, green infrastructure, water management systems, and strategic planning.

Traditional mud brick building is extremely moisture-prone. According to Ndububa, & Mukaddas, (2016), 76% of examined mud homes in Bauchi had wall collapses with compressive strengths of $0.81 N/mm^2$, which is much lower than the national standard of $2.5 N/mm^2$. This needed material innovation. Compressed Stabilised Earth Blocks (CSEB), which include 5-10% cement, preserve structural integrity under dampness and 85% of their strength after 24 hours of immersion.

Humanitarian inventions followed suit. The Muna Type Transitional Shelter has enhanced structural connections and lower-absorption materials for quick, flood-resistant deployment (Mercy Corps, 2024). Similarly, the Birkaroon latrine employs polypropylene bags to offer pit stability in flood-prone terrain for half the cost of traditional brickwork, hence reducing the spread of waterborne infections during flooding.

2.4 Energy-Architecture Nexus

A major gap in existing research is the failure to connect building design to decentralised energy availability. Nigeria's 2013 electricity industry privatisation failed to yield results due to decades of underinvestment and lax oversight. With the national system regularly failing until 2026, Nigerians rely on generators for 40% of their electricity, resulting in $26 billion in yearly commercial losses (Obazee, 2026).

However, community-scale microgrids offer a viable alternative. Solar PV/battery systems at Kabuiri village produced power for $0.093 per kWh, with 99% renewable penetration (Lewis *et al.*, 2024). The Distributed Access via

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Renewable Energy Scale-up (DARES) initiative is now scaling up this decentralised strategy (World Bank, 2026; Wedoany, 2026). DARES, which was started in 2024 with $750 million from the World Bank, intends to remove 280,000 generators and link 17.5 million Nigerians.

Mini-grids and solar residential systems are further supported by the ₦170 billion budget for the Rural Electrification Agency in 2026. The best approach to react to climate change is to combine these decentralised energy technologies with passive architectural design. For instance, solar PV may provide a robust, off-grid habitability model by powering basic lights and ventilation in a structure that has already been optimised via passive cooling to consume less energy. Additionally, since fuel subsidies were eliminated in late 2023 and early 2024, the cost of running petrol generators has tripled, making solar-integrated structures not only better for the environment but also more affordable for the impoverished in both urban and rural areas.

2.5 Policy Frameworks and Implementation Barriers

Nigeria's policy framework is robust, yet it confronts major implementation challenges. The National Building Code, the BEEC (2017), and the 2025 MEPS for Air Conditioners are among the key tools. The Nationally Determined Contributions (2021) pledge to a 47% conditional emission reduction by 2030, with buildings identified as a priority sector. The Energy Transition Plan (2022) aims to achieve net-zero energy by 2060, which would require more than $410 billion in finance.

Despite this, Nigeria ranks 15th out of 43 countries on the AfDB's Electricity Regulatory Index 2024, with high governance (0.897) but poor service delivery results (0.512). Primary impediments include budgetary limits, technical inadequacies in the building industry, and a lack of enforcement. Conflict has eroded institutional capacity in the Northeast even further. Furthermore, the 2024 National Energy Compact (Mission300) seeks a 50% renewable share by 2030, needing $15.5 billion in private investment.

The "Home After Crisis" idea and similar design advances indicate that the way forward is to combine local material economies with new technology standards. This necessitates a shift from compartmentalised answers to a cohesive framework in which architects, energy engineers, and humanitarian actors work together. In displacement scenarios, the hurdle is frequently the "emergency mindset," which prioritises short-term quickness above long-term durability. Moving toward a "Build Back Better" strategy necessitates incorporating these technical standards into the procurement and finance methods employed by international NGOs and the Ministry of Humanitarian Affairs. Without localised technical training and the incorporation of these rules into humanitarian shelter protocols, these standards will remain aspirational.

Table 1: Nigeria's Policy Implementation Gap

Indicator	*Score*	*Interpretation*	*Source*
Regulatory governance	0.897	Strong frameworks exist	African Development Bank (2024)
Quality of service delivery	0.512	Weak consumer outcomes	African Development Bank (2024)
Customer metering	46.57%	Cannot bill half of consumption	NERC 2024 Annual Report
Grid collapses (2024)	9	Systemic reliability failure	NERC 2024 Annual Report
Per capita consumption	140 kWh	95% below global average	World Bank (2024)
Population without grid access	40% (90 million)	World's largest deficit	Multiple sources

III. METHODOLOGY

This study takes a qualitative case study method, synthesising data from peer-reviewed literature, technical reports, and recorded initiatives in Borno and Adamawa states, Nigeria. The technique prioritises triangulation across several evidence streams to address the scarcity of region-specific primary data due to continuous war and considerable geographical access barriers.

African Journals Online (AJOL), ScienceDirect, Scopus, and institutional repositories were all thoroughly searched in January and February of 2026. Among the keywords were "flood-resistant structure," "Hausa architecture climate," "passive cooling Nigeria," and "energy access Northeast Nigeria." In order to include current climate estimates and post-2015 humanitarian responses, the search timeframe was 2015–2026. After screening an initial yield of 87 papers for contextual relevance and empirical rigour, 34 peer-reviewed publications and 12 reports on grey literature were ultimately included.

Humanitarian organisations such as Mercy Corps (Muna Shelter), Solidarós International (Birkaroon latrine), UN-

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Habitat, and the IOM provided the reports. The World Bank, REA, and the Federal Ministry of Power provided the policy data. Critical Appraisal Skills Programme (CASP) criteria were used to evaluate peer-reviewed papers, while authority, transparency, and documentation quality were considered when evaluating grey literature.

Braun and Clarke's (2006) six-phase methodology was used for thematic analysis. Research questions and implementation patterns were the deductive and inductive sources of themes. The approach acknowledged the interdependence of both areas and specifically looked at the relationship between energy and architecture. Standardised measures from IRENA (2024) and the AfDB (2024) were used for comparative benchmarking against regional counterparts (South Africa, Morocco, and Rwanda).

The study makes use of secondary data that is accessible to the public (e.g., Eyiah-Botwe, 2026). The review intentionally sought for unfavourable findings (e.g., Ndububa, & Mukaddas, 2016) to reduce publication bias, even though conflict still limits primary data. The absence of longitudinal data for current flood developments in 2024 and the scarcity of sex-disaggregated data for gender analysis are among the limitations.

IV. RESULTS

4.1 Research Question 1: Passive Cooling Techniques

Finding 1.1: Temperature Reduction Potential

Simulation studies and post-occupancy evaluations from similar Nigerian situations give strong quantitative evidence for passive cooling performance. Adaji's (2017) doctoral research in Abuja's low-income settlements found that the best combinations of passive cooling interventions including roof insulation, wall insulation, and external shading lowered indoor maximum temperatures by more than 5°C (range 4.2°C to 5.8°C) in naturally ventilated buildings. For air-conditioned dwellings, these changes resulted in monthly energy cost savings of N8, 110 (about £16.97), which is 45% of Nigeria's national minimum wage, illustrating the economic importance of passive design for low-income households.

A thorough study of passive cooling solutions in African contexts validates similar findings, stating that integrated approaches result in 3-5°C indoor temperature decreases and a 20-60% reduction in cooling energy consumption. The research emphasises that efficiency is strongly dependent on climate context, with cross-ventilation and shade operating best in hot, humid locations and high thermal mass being most significant in arid regions such as the Sahel. Critically, the research discovered that "the use of historical and vernacular designs boosted adaptation, especially when paired with modern advances like as reflective coatings and PV shading"a result that is directly relevant to the region's Hausa architectural legacy.

Abdulkareem and Al-Maiyah's (2025) verified simulations revealed that passive design combinations might lower thermal discomfort frequency by 8.5 to 19.5 percent during the warmest times. Shading devices, such as verandas, made a substantial contribution to these reductions, demonstrating the importance of the traditional “zaure” feature. Their findings revealed that residents in buildings without shade suffered discomfort for 6-8 hours per day during peak summer months, compared to 2-3 hours in buildings with optimised shading.

Finding 1.2: Nature-Based Solution Efficacy

Akinwolemiwa *et al.* (2018) tested green wall systems in low-income Lagos areas and found that they reduced interior temperatures by an average of 2.3°C (SD 0.4°C). During monitoring periods, the systems maintained internal comfort levels ranging from 90 to 100%. These initiatives were executed with populations living on less than £1 per day, proving their viability in severe poverty settings. However, the study emphasised that continued maintenance necessitated community organising, which may not be repeatable in all situations, particularly when relocation breaks social networks.

Finding 1.3: Applicability to North Eastern Contexts

While actual post-occupancy data from Borno and Adamawa remains restricted due to conflict-related access limitations, climatic similarities between Abuja and Lagos warrant extrapolation from their findings. Traditional Borno complexes have historically accomplished thermal comfort through thick mud walls (600-800mm) with high thermal mass, deep verandas shading interior rooms, and courtyard designs that promote air circulation all without mechanical equipment (Moughtin, 1985). However, study found an "alarming gap over the abandonment of basic sustainable design methods when addressing the demands of low-income housing" (Abdulkareem and Al-Maiyah, 2025), which exactly describes situations in Borno and Adamawa.

Finding 1.4: Policy Innovation in Cooling

The approval of new Minimum Energy Performance Standards (MEPS) for air conditioners in June 2025 marks a significant policy breakthrough. The standards, established with UNEP technical help, aim to hasten the transition to energy-efficient and climate-friendly cooling, with implementation set for 2026. This program targets cooling-

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related pollutants while potentially lowering energy demand for mechanical cooling.

Finding 1.5: Barriers to Adoption

Documented barriers include upfront costs that add 5-15% to construction (Alegbe *et al.*, 2025); knowledge gaps, with 78% of Borno artisans lacking climate-responsive design training (Mercy Corps, 2024); the absence of code enforcement in Borno and Adamawa; and maintenance requirements that displaced populations may not be able to meet.

Table 2: Documented Passive Cooling Performance

Intervention	*Temperature Reduction*	*Energy Savings*	*Study Quality*	*Replication Status*
Combined passive design	>5°C (range 4.2-5.8)	45% of min. wage	Peer-reviewed PhD	Not replicated in North East
Multiple strategies (systematic review)	3-5°C	20-60% cooling demand	Systematic review (10 studies)	Confirmed across African contexts
Shading devices	8.5-19.5% discomfort reduction	Not quantified	Validated simulation	Not field-validated in region
Green walls	2.3°C average (SD 0.4)	Not quantified	Peer-reviewed trial	Single study, needs replication

4.2 Research Question 2: Flood-Resistant Structural Strategies

Finding 2.1: Transitional Shelter Performance

Mercy Corps (2024) documentation on the Muna Type Transitional Shelter, implemented in the Jere Local Government Area, demonstrates specific flood-resistant features, including windstorm resistance through improved structural connections, lower water absorption rates using stabilised soil blocks, rapid construction (7-10 days per shelter), and locally sourced materials. The shelter enabled deployment to 2,500 homes, with post-occupancy assessments at 6 months revealing that 92% remained completely functional, compared to 64% of typical mud brick shelters in nearby locations.

Finding 2.2: Material Innovation Outcomes

Compressed stabilised earth blocks (CSEB) have two advantages: greater flood resilience than ordinary mud bricks and improved thermal performance due to large thermal mass (Sabon Gida and Sabon Farko, 2024). Laboratory tests revealed that CSEB water absorption was 8-12% compared to 20-25% for traditional mud bricks, with compressive strength retained at 85% after 24 hours of immersion (Building Materials Research Institute, 2023).

Ndububa, & Mukaddas (2016) assessed 67 mud dwellings in Bauchi and discovered that about 76% had undergone wall collapses. Laboratory testing found an average compressive strength of 0.81 N/mm², far lower than the Nigerian norm of 2.5 N/mm² for sandcrete blocks.

Finding 2.3: Sanitation Infrastructure Innovation

European Commission (2024), launched the Birkaroon latrine during the Maiduguri floods in September 2024, and it garnered amazing adoption metrics. User acceptance rates reached 98 percent among 1,000 installed devices servicing around 6,000 persons. Key qualities include a construction cost of $50-70 (less than half that of traditional pits), a 5-hour installation time by three untrained people, materials made from locally accessible garbage, and zero failures over three months of monitoring despite flooding. Women's involvement in siting decisions was critical: units located with women's input received 99% approval compared to 87% without.

Finding 2.4: Flood Impacts on Energy Infrastructure

The Maiduguri floods significantly devastated electricity infrastructure, leaving 47 distribution transformers underwater, 124 km of lines damaged, and 85% of impacted consumers without power for 2-6 weeks (Nigerian Electricity Regulatory Commission, 2025). This left people without electricity at critical times for water pumping, emergency lighting, and communication, emphasising the importance of decentralised, climate-resilient infrastructure.

Finding 2.5: Negative Findings and Failures

Conventional mud brick rehabilitation is consistently vulnerable, with 76% failure rates in Bauchi (Ndububa, &

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Mukaddas, 2016) and 40-60% failure within 48 hours after floods (European Commission, 2024). Solar home system installations on substandard constructions resulted in 15% requiring reinstallation after six months (Mercy Corps, 2024). Gender-blind consultation resulted in 30-40% under utilisation rates.

Table 3: Flood-Resistant Innovation Comparison

Innovation	*Cost*	*Installation Time*	*User Acceptance*	*Key Feature*	*Failure Rate*
Birkaroon latrine	$50-70	5 hours (3 workers)	98%	Conical pit stability	0% (3 months)
Muna Shelter	$850-1,200	7-10 days	92% (6 months)	Low water absorption	8% (6 months)
CSEB construction	$12-15/m²	Standard	Not quantified	Moisture resilience	Not documented
Conventional mud brick	$8-10/m²	Standard	64% (6 months)	Traditional but vulnerable	36% (6 months)

4.3 Research Question 3: Community-Based Adaptation Strategies

Finding 3.1: Participatory Design Outcomes

The "Home After Crisis" project (Sabon Gida, SabonFarko, 2024) documented the following outcomes of community-engaged design: increased ownership (78% reporting "strong sense of ownership" versus 34% in conventional programs), skill development (124 community members trained in CSEB production), and economic benefits ($45,000 in local wages). The incremental housing model used an L-shaped module that could be gradually upgraded as resources allowed.

Finding 3.2: Economic Integration Impacts

Mercy Corps (2024) found that THRIVE program shelter building employed 850 local craftspeople, with average incomes of $180, equivalent to 2-3 months of household income. The "Home After Crisis" idea freed up underutilised space for income-generating activities, perhaps limiting recruitment into insurgent groupsthough long-term data is yet unavailable.

Finding 3.3: Local Material Economy Development

Both the Muna Shelter and CSEB efforts established the possibility of locally sourced material supply chains, which reduced transportation costs by 40-60%. Borno State created three community-based CSEB manufacturing firms in 2024, generating 15,000 blocks and employing 45 people.

Finding 3.4: Energy Community Emergence

Lewis et al. (2024) documented community-scale microgrid implementation in Kabuiri village: solar PV/battery systems achieved levelized electricity costs of $0.093 per kWh with 99% renewable penetration, low environmental impact (1,624 kg CO_2 eq/year), and system adaptability without significantly increasing costs. Community ownership and management were key success elements.

At the national level, the DARES initiative, which has received $750 million in World Bank support, aims to install 17.5 million new connections while removing 280,000 diesel generators (World Bank, 2026; REA, 2026). The Rural Electrification Agency's 2026 budget of ₦170 billion includes more than 500 electrification projects (Premium Times, 2026; Radio Nigeria, 2026; Voice of Nigeria, 2026).

Finding 3.5: Gender Dimensions

Women's participation is associated with higher acceptance (Birkaroon: 99% with women's input vs. 87% without); women-headed households (30-40% of displaced populations) face additional barriers to participation; and no documented intervention systematically tracked gender-differentiated outcomes, according to the limited gender-disaggregated data.

Finding 3.6: Barriers to Community Participation

Documented impediments include humanitarian timescales that prevent meaningful interaction, financial arrangements that prioritise outcomes over processes, elite capture that excludes marginalised communities, and chronic gender exclusion despite verbal promises.

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Table 4: Community-Based Adaptation Outcomes

Intervention	*Participation Mechanism*	*Documented Benefit*	*Gender Consideration*
Home After Crisis	Design + construction	78% ownership (vs 34% conventional); 124 trained; $45,000 wages	Not specified
THRIVE Shelter	Local employment	850 workers; $180 average earnings	Not specified
Birkaroon latrine	User consultation	98% acceptance	Women's input critical (99% vs 87%)
Kabuirimicrogrid	Community ownership	$0.093/kWh LCOE; 99% renewable	Not specified
DARES Programme	Private sector-led	17.5 million target connections	Not specified

V. DISCUSSION

Concerning trenclimate vulnerability and energy poverty in North Eastern Nigeria are not separate concerns, but rather interconnected crises. The region risks increasing temperatures (4.1-5.2°C by 2100), regular flooding (like as the 2024 Maiduguri disaster), and a 90-million-person energy access shortfall, with rural electrification at less than 30%.

These disasters exacerbate cascading vulnerabilities. Heat stress increases cooling demand precisely when the frail system fails nine times in 2024, leaving even linked families without electricity (Obazee, 2026). Floods devastate both homes and energy infrastructure; the Maiduguri floods buried 47 transformers, leaving 85% of customers without electricity for weeks, when it was most required for water pumping and communication (NERC, 2025).

The national grid's fragility, characterised by poor "observability and protective discipline," requires a $26 billion yearly reliance on generators (Obazee, 2026). Women incur disproportionate costs, including gender-based violence during fuelwood collection and indoor air pollution, which kills 98,000 people per year (WHO, 2022). Despite leading 30-40% of displaced families, women are still marginalised in decision-making.

Evidence shows both promising advances and chronic failures. What works: Passive cooling, which uses traditional Hausa characteristics such as zaure verandas and tsakargida courtyards, decreases temperatures by more than 5°C and saves 20-60% on cooling energy (Adaji, 2017; Eyiah-Botwe, 2026). The new 2025 MEPS for air conditioners gives regulatory levers, whereas Compressed Stabilised Earth Blocks (CSEB) offer greater flood resilience, holding 85% strength after immersion compared to typical mud bricks' 76% failure rate (Adamu *et al.*, 2016; NBRRI, 2023). Furthermore, the Birkaroon latrine received 99% user acceptability after female consultation (European Commission, 2024), while the DARES initiative seeks to reach 17.5 million people with decentralized microgrids (World Bank, 2026).

In flood-prone locations, conventional mud brick restoration fails 76% of the time ((Ndububa, & Mukaddas, 2016). Solar house systems built on structurally insufficient roofs have a 15% failure risk within months (Mercy Corps, 2024). Most critically, siloed planning continues to fail; architectural and energy interventions are designed in isolation, missing synergies that reduce cooling loads by 45% (Adaji, 2017). This "structural incoherence" and lack of inter-agency coordination (Obazee, 2026) exacerbate vulnerability, keeping low-income communities in the dark as policy implementation falls behind framework development (AfDB, 2024). Integration is no longer a choice; it is necessary for existence.

Comparison: Nigeria in Regional and Global Context

Nigeria has the world's highest energy deficit, at 90 million people, which is due to coordination errors rather than resource constraint. Regional comparisons provide important policy lessons: South Africa's 13,516 MW of renewable capacity dwarfs Nigeria's 3,079 MW (Diop, 2025), while Rwanda's transition from 6% to 63% access (2009-2023) demonstrates the power of dedicated institutions and sequential grid strategies (Rwanda Energy Group, 2024).

Grid dependability remains a unique concern; Nigeria's nine outages in 2024 contrast with South Africa's managed load-shedding. Systematic rehabilitation of deficient "observability and protective discipline" is necessary (Obazee, 2026). In architectural policy, Morocco's incorporation of

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ancient ideas into current standards resulted in 40% energy savings (El Hafdaoui, *et al.*, 2023), reinforcing the fact that integrated tactics provide better outcomes.

Furthermore, Colombia's successful subsidy adjustments highlight the need of pre-announced modifications and social safety nets (IMF, 2024) in avoiding the energy poverty increases witnessed in Nigeria. Finally, Rwanda's 30% female participation in building demonstrates that conscious design may bridge the gender inequalities that impede Nigerian solutions.

The Energy-Architecture Integration Gap

Research demonstrates a near-total lack of integrated approaches to building design and energy availability in North Eastern Nigeria. This domain split, caused by fragmented ministries and financing, undermining both housing and energy results.

Shelters constructed without energy concerns lack battery storage space and structural stability for solar installation, resulting in recorded 15% failure rates. Conversely, energy treatments frequently use systems for housing that lacks interior wiring or connecting ports. Furthermore, disregarding synergies results in missed cost reductions; for example, passive design can cut cooling loads by 45% (Adaji, 2017).

Timing mismatches also persist: house restoration frequently starts quickly after a disaster, but energy infrastructure takes years. While experiments like as the Kabuiri microgrid (Lewis et al., 2024) demonstrate the feasibility of community-scale renewables, coordination is still rare. In contrast, Rwanda's Integrated Settlement Policy requires multi-sectoral energy and water planning before to building (Ministry of Infrastructure, 2022). Without equivalent institutional coordination between Nigeria's DARES project and humanitarian organisations, vulnerabilities worsen and possibilities for resilient recovery are missed.

Barriers to Scaling: Policy, Finance, Capacity, and Gender

Despite established efficacy, four interrelated impediments prevent sustainable architecture and energy practices from becoming the norm in North Eastern Nigeria.

- Policy fragmentation results from lax enforcement of building rules and high energy objectives in the informal sector. Inadequate inter-ministerial coordination across the power, housing, and humanitarian sectors impedes integrated climate-responsive planning (Guardian, 2025; Ministry of Infrastructure, 2022).
- Financial restrictions favour immediate shelter over long-term success. The DARES initiative offers $750 million in World Bank finance and ₦1 trillion in local credit for electricity (REA, 2026; World Bank, 2026). However, there are no comparable mechanisms for resilient housing.
- The knowledge and ability gaps are substantial; 78% of Borno State craftsmen lack climate-responsive design training (Mercy Corps, 2024). This is exacerbated by the decline of traditional Hausa cooling practices among younger generations.
- Gender inequality excludes women from decision-making, despite evidence that their participation, as demonstrated with the Birkaroon latrine, assures success (European Commission, 2024). The failure to track gender-differentiated effects reduces the effectiveness of climate measures.

Implications for Policy, Practice, and Research

Integrate housing and energy by integrating the National Energy Compact and the Building Energy Efficiency Code (Guardian, 2025). Professional certification can help enforce laws in informal building. Scale successful models by supporting the DARES goal of 17.5 million connections (World Bank, 2026; REA, 2024). Create interministerial cooperation for climate adaptation based on Rwanda's Integrated Settlement Policy (Ministry of Infrastructure, 2022). Gender mainstreaming requires disaggregated data and involvement.

Design for integration with solar-ready roof structures (20kg/m²) and battery storage. Prioritise flood-resistant, thermally efficient materials such as CSEB over ordinary mud bricks, which have a 76% failure rate (Ndububa, &Mukaddas, 2016). Move beyond consultation and into actual community and female participation. Take a gradual, multi-sectoral strategy from site selection to execution.

Prioritise longitudinal studies of passive cooling and shelter durability in North Eastern areas. Evaluate the costs and gender-specific effects of integrated treatments. Calculate cost-benefit ratios for averted damages and health. Systematically document failures to combat publishing bias and enhance future crisis response.

VI. CONCLUSION

Climate change poses an existential danger to housing in North Eastern Nigeria, with predicted warming of 5.2°C, rising floods, and a national energy shortfall of 90 million unmet needs. This research reveals that while successful adaptations exist, like passive cooling that cuts temperatures by 3-5°C (Eyiah-Botwe, 2026), flood-resistant shelters, and microgrids supplying electricity for $0.093/kWh (Mercy

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Corps, 2024), these innovations remain exceptional rather than normative (Lewis *et al.*, 2024).

The gap between possibility and reality reveals substantial policy fragmentation and gender disparities. Nigeria's regulatory governance score (0.897) greatly outstrips its actual outcomes (0.642) (African Development Bank, 2024), a disparity highlighted by nine grid failures in 2024 and over half of all consumers lacking metering (Obazee, 2026). Architectural and energy systems continue to be planned separately, compromising mutual resilience. Furthermore, women face disproportionate climate burdens yet are under-represented in solution formulation.

The 2025/2026 Minimum Energy Performance Standards (MEPS) and the DARES plan (Guardian, 2025), which aims to add 17.5 million additional connections, are promising change levers (World Bank, 2026; REA, 2026). However, meeting these objectives necessitates the following priority actions:

- Coordinate inter-ministerial efforts to implement building regulations and energy compacts.
- Integrated Design: Include energy-saving features like solar-ready roofs and battery storage in shelter requirements.
- Improve grid stability by addressing systemic weaknesses in observability and revenue collection.
- Encourage women's engagement and provide gender-disaggregated statistics.
- Green banking partnerships provide innovative financing to cover the upfront expenses of passive design.

For millions of people in the Northeast, adaptability is essential for survival. Nigeria has the solar potential, institutional frameworks, and recorded advances necessary for a sustainable future. The route forward requires political resolve to collaborate across sectors, stabilise the grid, and guarantee that vulnerable populations shape their own settings.

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