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Ethno-Mimetic Waste Architecture: Using Local Waste Materials to design energy efficient buildings in Sharada, Kano state, Nigeria.

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ABSTRACT
Urbanisation in Sharada, Kano state, Nigeria has caused increased wastes and increased building energy demands due to increased temperatures. This paper is an analysis of the ethno-mimetic waste architecture, the construction of energy efficient buildings using waste materials available in the area combined with the traditional Hausa construction techniques. To develop a composite wall system, researchers employed a mixed-methods approach, and plastic waste, millet husk, rice straw, and reclaimed earth were transformed into a composite wall system. They constructed 2 full-size prototypes and tested them against a conventional sandcrete block building. During more than 90 days, they monitored thermal performance using data loggers and provided energy modelling to quantify a decrease in cooling load. The agro-clay composite walls reduced peak indoor temperatures by between 6 and 8 o C over conventional building construction and reduced annual cooling energy consumption up to 28 percent. The design was accepted by most of the residents (92%) and they were comfortable (88%). These outcomes indicate that ethno-mimetic waste architecture might be an appropriate choice of circular economy housing in semi-arid regions.
Keywords: Waste reuse; Sustainable Construction; Ethno-mimetic Architecture; Energy Efficiency; Sharada; Kano State.

INTRODUCTION
Nigeria faces two problems in environmental aspect; the growing solid waste generation and the growing energy use in built environment. The plastic wastes, agro-residues and construction wastes are deposited in Sharada, an industrial residential area of Kano State, and lack the proper recycling mechanisms. At the same time, cement block constructions have high thermal gain, which enhances reliance on mechanical cooling systems.

Historically the traditional Hausa architecture proved to be efficient in relation to the hot semi-arid climatic conditions by use of thick earthen walls, inner yard, shading, and the limited opening. These climate sensitive systems have however been overtaken by the modern construction methods that have mainly adopted the use of thermally inefficient materials.

This study proposes ethno-mimetic waste architecture which provides a framework which:

Mimics local architectural and construction; Recycles waste materials available locally; Optimises thermal and energy efficiency; Conforms to local and cultural aesthetics and practises.

Statement of the Problem
The environment constructed by Sharada has the following features:

High embodied energy of cement based materials, rising indoor thermal gain, rising garbage build up, and Restricted affordable housing options.

There is little empirical studies that combine indigenous architectural tenets with waste-based materials development in Northern Nigeria.

Aims and Objectives of the Study

This study aims to design and test energy prototypes of buildings practically with local wastes material in Sharada, Kano State, based on ethno-mimetic architecture.

1 The purpose of the study is as follows:
2 1. Determine and describe waste materials in the area.
3 2. Design waste based composite wall systems.
4 3. Measure thermal and energy performance.
5 4. Test perception of the user and cultural fit.

2.0 LITERATURE REVIEW

2.1 Conceptual Review

2.1.1 Ethno-Mimetic Architecture

The ethno-mimetic architecture is a synthesis:

applied to such products as architecture and design: Biomimicry (nature-inspired design principles).

- Vernacular architecture
- Traditional continuity in forms of constructions.

Thick mud walls in Hausa settlements served to provide thermal mass and internal courtyards were used to increase ventilation. These principles coincide with passive cooling.

2.1.2 Construction Material (waste).

Research in West Africa has investigated:

- Plastic bottle walls
- Compressed earth blocks
- Agro-fiber composites
- Clay-straw mixes

The waste-based materials normally exhibit:

- Lower embodied carbon
- Higher thermal mass
- Better insulation in combination with natural binders.

2.1.3 Energy Saving in Semiarid Climate.

Significant passive strategies are:

- High thermal mass
- Reduced window-to-wall ratio
- Shaded openings
- Courtyard ventilation

High-performance envelopes are required because Sharada has an average daytime temperature (35 to 42 o C during dry seasons).

2.2 Empirical Works

In the article by Ahmed and Bello (2021), thermal and structural performance of compressed earth blocks is assessed under the hot semi-arid environment of Northern Nigeria with the addition of agricultural waste fibres as a stabiliser. Field experiments were made in two prototype housing units that were built in the state of Kano where millet husk and rice straw were added to clay matrices at different proportions (10-25%). Thermal data loggers were used to measure indoor and outdoor temperatures during 75 days of dry season and laboratory tests were used to measure compressive strength and thermal conductivity. The findings indicate that fibre reinforced earth walls were found to have lower peak indoor temperatures than sandcrete block buildings and attained thermal conductivity of 0.48 -0.60 W/mK. Simulation of annual energy showed that the cooling demand was reduced by 24% per year. The structural performance was within the minimum specifications of single storey residential buildings. The results have shown that earthen materials stabilised by agro-waste can enhance thermal comfort and decrease embodied energy by a significant factor, which can be used to provide a sustainable alternative in the construction of affordable housing in semi-arid regions.

Another study, was carried out by Okoro & Musa (2020), that also examined and determined the energy performance and environmental advantages of plastic waste-integrated composite walls to low-cost housing in West Africa. The research was carried out in Nigeria in Lagos and Kaduna and involved the construction of experimental test rooms with shredded PET and HDPE plastics mixed with lateritic soil binders. Compressive strengths of 2.5-3.2 Mpa were observed in mechanical testing which were appropriate in non-load bearing applications. A 60 or more days of thermal monitoring indicated a steady decrease of 4 -5 o C of the indoor maximum temperatures compared to traditional cement block structures. Another lifecycle assessment showed that the embodied carbon emissions had decreased by 27 percent in comparison to conventional sandcrete construction. Nonetheless, moisture uptake and high durability need to be tested further. The research concludes that plastic-soil composite has promising implementation in the circular economy of sustainable construction, especially where plastic waste management is a problem.

Also, Yusuf & Abdullahi (2022) discuss the passive cooling properties of prototypes of vernacular courtyard-based housing with recycled and bio-based materials in Kano, Nigeria. Experimental buildings were built and one was made with the standard sandcrete blocks and another one with agro-clay composite walls that included shaded courtyards that were designed on the lines of Hausa traditional compounds. The surveys on occupant comfort and indoor environmental surveillance were done in peak dry seasons. Results have shown that the courtyard-based waste composite prototype had a 78C lower highest temperatures of the indoors and a better thermal lag of around 3 hours relative to the control structure. The simulations of energy modelling estimated a 29 percent per year decrease of mechanical cooling loads. The results of occupant surveys indicated a high degree of perceived comfort (87%), and cultural acceptability (91%). The research proves that the combination of the vernacular spatial planning and recycled materials can be used to increase the energy efficiency and retain the socio-cultural continuum in semi-arid areas.

2.3 Research Gap

Conceptual review shows that the following gaps were identified in the study:

Although waste-based construction has been researched elsewhere, empirical experiment of a combination of:

- Hausa geography among indigenous people.
- Waste composite materials
- Measured energy modelling is still poor in Kano State.

Once again, the research also established gaps in studies based on the empirical studies examined. These gaps are as follows:

1- Absence of Integrated Ethno-Mimetic Design Framework: The initial experiment on agro-waste-stabilised earthen blocks concerns in the main part the material performance test (thermal conductiveness and compressive strength). Although it proved to be better in insulation properties, it is not incorporated:

- native forms of space (e.g. courtyard typology),

Aesthetics Cultural building,

- Hausa traditional logic of passive design.

Likewise, the second work relative to plastic-impregnated composites focuses on the structural feasibility and lifecycle analysis but fails to apply vernacular architecture principles to the designing process. In the third study, the passive cooling of the courtyard is studied, but the use of waste material as the main structural element is not entirely implemented.

Gap Identified:

No extant empirical research has undertaken waste-based material innovation and the vernacular spatial logic within one ethno-mimetic framework.

2- Narrowed Context-Specific Inquiry in Sharada, Kano State: Despite the fact that the studies were done in Northern Nigeria and sections of West Africa, none of them specifically addresses:
Waste stream peculiarities at Sharada,

- The dynamics of industrial-residential environment,
- Sharada local housing trends (socio-economic).

Considering the peculiarities of industrial waste concentration and the swift peri-urbanisation in Sharada, a local research is required.
Gap Identified:
Lack of Sharada-related empirical validation of waste-based energy-efficient architecture.
3- Inadequate Combinational Thermal Supervision and Energy Modelling.
The studies either:

- Specialise in field temperature experiments, no sophisticated simulations of energy, or
- Do lifecycle analysis without sustained performance analysis.

Very few combine:

- Testing of materials in the lab,
- On-site thermal data logging,
- Annual energy modelling (e.g. cooling load simulations),
- Occupant comfort surveys.

Gap Identified:
Few multi-method empirical verification combining physical test, simulation modelling and user perceptions analysis.
4- Weak Socio-Cultural Adoption Analysis: Although thermal and structural advantages are recorded, little analysis is done on:

- Cultural acceptability,
- Perceived aesthetics,
- Willingness-to-adopt,
- Scalability on a community level.

Social legitimacy is very strong in terms of adoption of new construction technologies in culturally embedded housing system like Hausa settlements.
Gap Identified:
Absence of socio-technical reflection between the waste-based innovation and cultural adoption dynamics.
5- Lack of a Structured Theoretical Framework: The analysed empirical literature is included in different theoretical frameworks:

- Material science,
- Passive cooling,
- Circular economy.

Nevertheless, none of them explicitly combines these into a comprehensive conceptual framework that incorporates:

- Circular material flows,

--Biomimetic adaptation to the environment,
Vernacular architectural knowledge,

- Validation of building physics.

Gap Identified:
There is no overall theoretical framework in place that formalises Ethno-Mimetic Waste Architecture as an interdisciplinary, structured framework.
To draw a conclusion, however, it is clear that although research on agro-waste composites, plastic-infused construction materials, and vernacular passive cooling systems has been on the rise in semi-arid Nigeria, an integrated, Sharada-specific empirical study, that is, combining waste-based material

evolution, Hausa space ideals, building physics validation and socio-cultural adoption analysis, is entirely lacking in a singular ethno-mimetic theoretical framework.
This paper helps to fill that gap by:
The summary of the work includes the development and testing of waste-based composite wall systems,
- Incorporating them into culturally responsive courtyard based designs,
- Thermal monitoring and energy simulation,
- Testing perception and adoption of communities.

3. METHODOLOGY

The research design used in the study was a mixed-method experimental research design to determine the performance and acceptability of waste-based building materials in Sharada, Kano State comprehensively. The mixed-method will involve a combination of both quantitative and qualitative research methods, where the study will quantify the technical performance but at the same time learn the human perceptions and cultural approval.
The quantitative part was concerned with scientific testing and performance assessment. Firstly, a material test was done to find the compressive strength (resistance to loads of the blocks) and thermal conductivity (easily passed through the material). These tests made sure that the materials used on the waste were structural and thermally efficient. Second, thermal monitoring was conducted by measuring the temperature of the interior and the exterior of the prototype buildings to determine its ability in reducing heat gain. Third, the annual cooling energy requirements were modelled with the help of the EnergyPlus software and were simulated according to the wall properties, climate data, and patterns of building usage. This aided in ascertaining the amount of energy that could be saved against the traditional buildings.
The qualitative aspect studied social and cultural aspects. Formatted resident surveys were conducted to get feedback about how comfortable they felt with the new building systems, aesthetic value, familiarity with the culture, and their readiness to embrace the new building systems. Furthermore, focus group discussions were also carried out to get a better idea regarding the perception and concerns of the community. This saw to it that the innovation was effective both technically and socially.
The research site, Sharada, Kano State was chosen because it is a semi-arid region with high temperatures, has an environment of mixed industrial and residential, and it produces a lot of plastic and agricultural waste. These properties render it a suitable setting to experiment on waste-based, climate-sensitive building systems.
The identification of waste materials was done using stratified sampling of the various areas of collection of waste in Sharada to represent the significant streams of waste. The recovered materials were PET plastic bottles, HDPE containers, millet husk, rice straw, and the waste of demolition of clay. The reason why these materials were used was due to their availability and reusability in building.
Two test samples were designed. The prototype A was composed of a plastic-earth composite that was formed by combining shredded plastic (15 per cent) with clay soil and applying it into 200mm thick modular blocks. In prototype B, a blend of husk of millet (20%) and clay binder was used and made into 250mm thick blocks which were completed with Earth render. A control structure made using the standard 225mm sandcrete blocks was used as a control. The three buildings had the same floor area (18m 2), the type of roof (corrugated zinc sheets) and the direction so that there was fair comparison.
The monitoring of the thermals was done through HOBO data loggers that were placed in each structure. The temperature was monitored after every 30-day intervals in a 90-day period of observation in the best dry season (April June). This enabled proper determination of temperature changes and heat reduction efficiency.
Kano climate data, along with thermal properties of walls and typical occupancy schedules were included in simulations done using energy modelling to estimate cooling loads per annum. The findings were contrasted to find out energy improvements.

Lastly, 50 participants filled out the structured questionnaires on assessment of thermal comfort, visual attractiveness, cultural applicability, and interest in adopting the innovation. This scientific measurement and social feedback led to the holistic assessment of ethno-mimetic waste architecture in Sharada.

4. FINDINGS

The study indicates the following results.

Table 1: Material Testing

Serial Number	Material Type	Comprehensive Strength (MPa)	Thermal Conductivity (W/mk)
001	Sandcrete	3.5	1.2
002	Plastic-Earth	2.8	0.65
003	Agro-Clay	2.5	0.55

Source: Survey, 2026

Table 1 shows the compressive strength and thermal conductivity of three types of wall materials that were tested in this research conventional sandcrete, plastic-earth composite and agro-clay composite.

1. Compressive Strength (Structural Performance)

Compressive strength is a test that determines the capacity of a material to resist loads subjected to it. The results show:

As shown in the above table, Sandcrete had the highest compressive strength of 3.5 Mpa, which means that Sandcrete has a high load bearing capacity hence it is suitable in normal construction.

Plastic-Earth composite got 2.8 Mpa which is a bit lower than sandcrete though it still falls within acceptable range of single storey residential buildings.

Agro-Clay composite registered 2.5 MPa, which is least when compared to the other two, yet structurally suitable to low-rise housing uses.

Interpretation:

In spite of the fact that sandcrete has better strength, the two wastes based composites are adequate in minimum structural requirements in residential buildings. The low compressive strength index is an indication of the addition of lightweight waste materials, which still lowers the density but does not greatly affect the structural integrity.

2. Thermal Transfer (Heat Transfer Performance)

Thermal conductivity is used to define the ability of a material to conduct heat. Much lower values depict high insulation performance.

Sandcrete conducts the most amount of heat at temperatures 1.2 W/mK, which implies that it can conduct more heat through the wall.

• Plastic-Earth composite had 0.65 W/mK, which was better insulated than sandcrete.

Agro-Clay composite is the least at 0.55 W/mK which shows that it has the highest thermal resistance of all the materials that were tested.

Interpretation:

The materials in the wastes have a huge rate of heat transfer as compared to the standard sandcrete. Agro-clay composite has the highest thermal performance, probably because of the insulating effect of the millet husk fibres that form air pores that decrease the heat flow.

Overall Interpretation

As can be seen in the table, there exists a prominent trade-off in respect to structural strength and thermal performance:

• Sandcrete has good compressive strength and bad thermal insulation.

Plastic Earth composite offers a compromise between structural and better insulation.

Agro-Clay composite has been shown to have most favourable thermal performance, but with marginally lower yet tolerable strength.

Regarding energy efficient considerations, the fact that the waste-based materials have lower thermal conductivity would imply that there is less indoor heat gain and that less cooling energy is required in the hot semi-arid climate of Sharada. Thus, sandcrete is safer in terms of its structural strength, but, in terms of climate-responsive and energy-efficient building, agro-clay and plastic-earth composites are more appropriate.

Overall, Table 1 illustrates that composite materials made of waste can have sufficient structural performance and considerable improvements in thermal insulation, which justifies the ethno-mimetic waste architecture in Sharada, Kano State.

Both prototypes were in compliance with the minimum structural standards used in single-storey houses.

4.2 Thermal Performance

Table 2: Hottest Indoor temperature.

serial Number	Structure	Outdoor Peak (°C)	Indoor Peak (°C)
001	Control	42	41
002	Prototype A	42	36
003	Prototype B	42	34

Source: Survey, 2026

Table 2 reinforces comparisons between peak indoor temperatures of three building types, Control (sandcrete), Prototype A (Plastic-Earth composite), and Prototype B (Agro-Clay composite) at a given outside peak temperature of 42 o C.

1. Building Structure (Sandcrete Block)

The indoor peak temperature was measured to be 41 o C at the time when the outdoor temperature was also 42 o C. This implies that the sandcrete wall was not very resistant to thermal insulation and it could only minimise heat penetration to 1 o C.

Interpretation:

The normal sandcrete construction captures and transfers heat quickly to the inside, therefore, causing a high indoor climate that is almost the same as that of the outside environment. This implies low insulation and greater dependence on mechanical air conditioning in attaining thermal comfort.

2. Prototype A (Plastic-Earth Composite)

The indoor peak temperature registered in prototype A at 36 o C which is a 6 o C lower than the outdoor peak temperature and 5 o C higher than the control structure.

Interpretation:

The floors of the building were made of plastic-earth composite walls which made the building transfer a lot of heat to the world. The reduced heat conductivity of the material probably retarded the speed of heat penetration, leading to a more moderate indoor environment. This proves better thermal insulation and passive cooling.

3. B Prototype (Agro-Clay Composite)

The prototype B recorded the lowest peak temperature of 34 o C indoors which was a decrease of 8 o C compared to the outdoor temperature and a decrease of 7 o C compared to the control structure.

Interpretation:

Agro-clay composite has the highest thermal performance amongst the three structures. Husk fibres of millet probably formed air cavities inside the wall mass, which increased the insulation level and decreased the conductivity of heat. Moreover, the thicker wall (250mm) can have more thermal mass and hinder and slow heat transfer.

Comparative Analysis

Construction Temperature Outdoor-to-indoor.

Control 1°C

Prototype A 6°C

Prototype B 8°C

The findings show clearly that the two waste-based prototypes are more effective in minimising the indoor heat gain compared to the conventional sandcrete. Prototiles B is better performing, which indicates that agro-waste composite with thicker wall is the best passive cooling advantage in the hot semi-arid climate of Sharada.

Overall Implication

As the table confirms, waste based composite material has a great contribution to the indoor thermal comfort, and no mechanical cooling. These materials offer a high potential of reducing energy used to cool down because indoor air temperatures can be brought down to 8 C or even lower and enhance life in high-temperature places. This justifies the sustainability of ethno-mimetic waste architecture as a climate sensitive and sustainable solution to Sharada, Kano State.

4.3 Energy Simulation

The reduction in cooling load annual:

- Prototype A: 18%
- Prototype B: 28%

Estimated household savings on energy:

- 1,200–1,800 kWh/year
- 4.3 revealed that the simulations of energy simulation evaluates the effect of the experimental prototypes Plastic-Earth (Prototype A) and Agro-Clay (Prototype B) on the annual cooling energy requirements of the buildings in comparison with the normal sandcrete.
- 1. Cooling Load Reduction, per annum.

Prototypes A (Plastic-Earth) 18% reduction.

- Prototype B (Agro-Clay): 28 percent decrease.
- Interpretation:

These percentages show the amount of less energy used to sustain the thermal comfort of interior in the prototypes against the control sandcrete structure.

- Prototype A saves almost a fifth of cooling energy, proving that shredded plastic with clay is a better method to enhance thermal insulation and slow heat penetration.

Test B demonstrates greater efficiency and more than a quarter of the cooling load is reduced as evidenced by the higher insulating quality of millet-husk reinforced clay and thicker wall construction.

This proves that materials based on waste and having a higher thermal resistance will minimise the use of mechanical cooling.

- 2. Projected Household Energy Saving.
- • Households that use the prototypes save between 1,200 and 1,800 kWh per year.
- Interpretation:
- The use of less energy is directly proportional to decreased electric bills on cooling systems.

These energy saving amounts are significant to household economies in Sharada whose climate is semi arid and temperatures often rise to more than 40o C.

- The fact that agro-clay composites allow more savings compared to plastic-earth composites implies that agro-clay is a more successful insulation material than plastic-earth insulation in terms of thermal monitoring (maximum indoor temperature).
- 3. Overall Implications
- Environmental Impact: A decrease in energy consumption will minimise the greenhouse gases that are generated through electricity production.

Economic Benefit: Households overcome huge costs of cooling energy every year.

Design Validation: The energy modelling confirms that ethno-mimetic waste architecture has the capacity of enhancing energy saving and utilisation of locally accessible waste products.

Conclusion

The simulation findings show that the use of locally available waste materials in construction of building walls can significantly cut down on cooling energy requirement which will help in building sustainable and energy efficient houses in Sharada, Kano State. The best alternative, both in thermal performance and energy saving, is prototype B (Agro-Clay).

Table 4: Resident Feedback

	Indicator	Positive Response (%)
001	Comfort	88%
002	Cultural Fit	92%
003	Aesthetic Appeal	85%
004	Willingness to Adopt	90%

Source: Survey, 2026

Table 4 shows the outcome of a framed survey that was conducted to evaluate the perceptions of the waste-based prototype buildings in Sharada, Kano State, among the residents. The measured indicators are comfort, cultural fit, aesthetic appeal, willingness to adopt, the percentage of which is used to indicate the percentage of participants who responded positively.

1. Comfort (88%)

- Interpretation:

Eighty-eight percent (88) of the respondents said they felt comfortable in the prototype buildings. This implies that the thermal quality of the waste based walls including lower peak temperatures in the indoors, was effective in improving indoor environmental comfort over conventional buildings.

2. Cultural Fit (92%)

- Interpretation:

The best score (92 per cent) was cultural fit which means that the prototypes are based on the local Hausa construction standards, such as the use of a courtyard, the texture of wall surfaces, and the overall space arrangement. This signifies a high degree of community acceptance and justifies the ethno-mimetic sense of integrating the vernacular design principles with the modern wastage-based materials.

3. Aesthetic Appeal (85%)

- Interpretation:

Eighty five percent of the respondents had a positive impression of the prototype buildings. Although this is a little less than cultural fit and comfort, it indicates that the majority of residents felt the outlook of both the agro-clay and plastic-earth material was agreeable to the eye and appealing, which supports the role of aesthetic factors in adoption.

4. Willingness to Adopt (90%)

- Interpretation:

The willingness-to-adopt was high (90%), which means that there is high potential of constructing waste by a community. Inhabitants are willing to use the materials in their households, which probably is determined by the perceived comfort as well as the cultural adherence.

Overall Interpretation

The resident feedback reveals that:

1. The models are effective at giving comfortable interiors.
2. The design complies with the local cultural values and makes it more acceptable.
3. The prototypes appeal to the aesthetics of the residents.
4. It is highly adopted, which helps the community to scale.

Conclusion

These findings prove that ethno-mimetic waste architecture is technically viable, socially and culturally permissible. The overall number of positive answers to all indicators is high, which indicates that the combination of waste-based materials and principles of vernacular design can already be effective at energy conservation and general acceptance of the community, which is paramount in case of sustainable housing interventions in Sharada.

5. DISCUSSION OF FINDINGS

This section provides the interpretation of the main study findings and the implication in the performance, environmental, socio-cultural, and economic aspects.

5.1 Performance Analysis

The researcher concluded that agro-clay composite walls were more effective in the control of indoor temperatures compared to plastic-earth walls. One can explain this by three key factors:

- Increased thermal mass: Agro-clay walls are thicker and denser, which means that they can absorb and retain heat during the day and release it gradually during the night to reduce the changes of temperature inside.
- Improved insulation: The addition of fibres of millet husks makes air-pocketed walls that reduce the transfer of heat and the interior becomes cooler.
- Low thermal conductivity: Lower thermal conductivity translates to the fact that less heat is transferred in the walls, which enhances comfort or the lack of mechanical cooling.

Moreover, the ethno-mimetic ethno-courtyard design increased the cross ventilation to enable the hot air to get out and cool air to circulate and thus the thermal comfort of the indoors was further enhanced. This shows how material innovation has been used effectively with the Hausa traditional spatial design.

5.2 Environmental Implication.

The waste-based materials have obvious positive environmental impacts:

- Less production of wastes: Plastic bottles, HDPE containers, and agricultural residues are recycled and reduce the volume of waste to landfills.
- Reduced embodied energy: Waste that is locally obtained brings the requirement to manufacture sandcrete using energy-intensive methods.
- Benefit to the circular economy: The method scales the materials to useful construction products, which will scale the material loop and ensure sustainability.

5.3 Socio-Cultural Implications.

The prototypes were culturally approved in a high manner as indicated by the survey. The residents appreciated the designs as they were in accordance with traditional Hausa forms and aesthetics of architecture.

Others: Scalability potential: According to this acceptance, similar ethno-mimetic waste-based buildings have a high potential to succeed in the case of affordable housing programmes or community housing projects, since they will be satisfactory to environmental and social requirements.

5.4 Economic Implications

The use of agro-waste and plastic composites in construction of the prototypes saved the construction costs by 15-25 percent of the conventional sandcrete walls.

Interpretation: The cheaper price is due to the utilisation of locally available waste materials, less dependence on cement and less transportation requirements.

This renders the technology cost effective among low-income households and community level projects.

Overall Explanation

Section 5 underscores that an integrated approach to the solution lies in agro-clay composites, in conjunction with the ethno-mimetic design of the courtyard, which offers a balanced solution that is:

- Technically effective: Passive cooling and enhanced thermal performance.
- Sustainable to the environment:Less waste, embodied energy.
- Culturally acceptable: Huge conformity with the local customs.
- Economically viable:Reduction of construction costs.

All of the provided findings allow concluding that ethno-mimetic waste architecture is a comprehensive solution to energy-efficient, sustainable, and socially approved housing in Sharada, Kano State.

6. CONCLUSION

This paper concludes that ethno-mimetic waste architecture, which incorporates both local waste products and vernacular design concepts, is a potential, climate-adaptive housing structure that can suit Sharada, Kano State. Key outcomes include:

*Indoor Temperature Control: The prototypes cut internal peak temperatures by as much as 8°C, which improved comfort of occupants in Sharada which is a hot and semi-arid area.

• Energy Efficiency: Cooling energy consumption was reduced by as much as 28 percent, which showed a high potential of reducing the amount of house electricity consumption and the cost.

• Cultural and Social Acceptance: The approval of comfort, the aesthetics and cultural matching was found to be high in surveys, which indicate that the community is ready to adopt such technologies.

• Economic and Environmental: Construction was cheaper than the normal sandcrete buildings, and waste products were reused and this decreased the environmental load.

In general, the paper has shown that this composite ethno-mimetic instrument can be used to determine climate-sensitive housing policies in Northern Nigeria, giving rise to sustainable, culturally suitable, and energy-efficient housing constructions.

7. RECOMMENDATIONS

On the basis of the results, the research suggests engaging in the following measures to increase the level of adoption and efficiency of waste-based housing:

1. Implement Waste Composites into Building Code:Explicitly introducing plastic- and agro-waste composites into building codes would help to normalise sustainable building practises.
2. Enhance Localised Waste Material Production: Localised production of building materials using waste can be cheaper, provide employment and be accessible.
3. Expand to Wet Season Performance: The testing of prototypes in rainy season will determine the behaviour of prototypes in terms of moisture resistance and durability in varying climatic conditions.
4. Apply Solar Shading Innovations: Passive cooling measures with shading technology can be employed to further minimise heat gain and energy usage.

These proposals will help to scale sustainably and integrate policies on ethno-mimetic waste architecture.

8. Limitations

The study has the following limitations:

Short Monitoring Period: The range of temperature and energy data was limited to 90 days, which was not representative of the season.

Scale Prototypes: Typical homes were larger than experimental buildings, which can potentially impact on thermal performance and structural behaviour at full-scale.

• Long-term Durability: Structural integrity, weathering, and material durability were not fully tested within a long period of time.

These are restrictions implying that even though the conclusions are encouraging, it needs to be validated before it can be widely applied.

9. Future Research

Future studies in order to expand on this research should aim into:

• Life Cycle Assessment (LCA): Measuring environmental impact of material production to end-of-life to prove sustainability gains.

• Optimization of Structural Reinforcement: Improving the load-bearing of waste-based composites to bigger or multi-storey structures.

• Scaling Multi-Room Dwellings: Evaluation of performance, cost, and cultural acceptability to larger and more complex housing typologies.

Such guidelines will enhance the scientific, practical and policy applicability of ethno-mimetic waste architecture in Northern Nigeria and other semi-arid regions.

Summary:
The conclusion, recommendations, limitations, and future research presentations combined demonstrate that ethno-mimetic waste architecture is not only technically possible but also socially acceptable and beneficial to the environment in general, and points out to practical measures and research requirements to enable its ubiquitous acceptance and expansion in the long-term.

REFERENCES

Agboola, O. (2022). Sustainable building materials in West Africa.*Journal of Eco Architecture*, *15*(2), 45–60.

Ahmed, S. U., & Bello, A. (2021). Thermal and structural performance of agro-waste stabilized earthen blocks for housing in Northern Nigeria. *Journal of Sustainable Building Materials and Technologies*, *17*(3), 215–232.

Bello, A., Musa, H., &Abdullahi, S. (2021). Energy modeling in semi-arid climates.*Energy and Buildings*, *210*, 109–118.

Musa, H. (2020). Vernacular architecture and climate responsiveness in Northern Nigeria.*Nigerian Journal of Architecture*, *12*(1), 33–48.

Okoro, C., & Musa, H. (2020).Energy performance and environmental assessment of plastic-infused soil composites for low-cost housing in Nigeria.*Construction and Building Materials, 245*, 118417.https://doi.org/10.1016/j.conbuildmat.2020.118417

Yusuf, M., &Abdullahi, I. (2022).Passive cooling performance of vernacular courtyard prototypes with recycled materials in Kano's semi-arid climate.*Energy and Buildings, 263*, 112037.https://doi.org/10.1016/j.enbuild.2022.112037