



Techno-Economic Analysis of Timber Modular Housing Solutions in Southwestern Nigeria

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Article information

ABSTRACT

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The study assessed firms' investment and operational capabilities, technological specifications and economic viability of timber modular housing development in Southwestern Nigeria. The study targeted Oyo, Ogun and Lagos States due to housing deficits and concentration of building and engineering firms in the States. An Infrastructure planning framework was employed for the study. Questionnaire survey was used to collect data from housing/infrastructure ministry officials and private-sector built-environment construction & engineering professionals in the study area. Results indicated that the predominant technological specifications for detached timber modular houses were 120 ft × 120 ft (50%), 60 ft × 120 ft (37.5%), and 60 ft × 60 ft (10%). The economic viability assessment revealed Present Worth (PW) and Annual Worth (AW) of ₦220 and 265.5 million respectively, indicating financial feasibility of timber modular housing development. The study concluded that timber modular housing development in Southwestern Nigeria is both technologically feasible and economically viable, and could serve as a sustainable and scalable alternative housing solution for the region.

Keywords: Modular housing solutions, Sustainability, Techno-economic analysis, Timber housing

INTRODUCTION

Nigeria faces an acute housing deficit, with over 28 million units required to meet existing demand (Infrastructure Policy Commission, 2024). This challenge is particularly pronounced in Southwestern Nigeria, especially in Oyo, Ogun, and Lagos States, where rapid urbanization, population growth, and economic expansion have outpaced housing supply (Oluwunmi, 2024). The existing housing delivery models in the country have proven inadequate due to the high cost of conventional building materials, rudimentary construction techniques, and poor infrastructure planning (Adenikinju, 2019; BPSR, 2025).

Modular housing, particularly timber modular construction, has emerged globally as a sustainable alternative capable of addressing cost, speed, and environmental challenges in the built environment (Ghannad et al., 2020; IPC, 2024). Timber prefabricated systems offer multiple benefits such as reduced construction time, less waste, energy efficiency, and lower life-cycle costs (Ghufran et al., 2022; Kazeem et al., 2024). In countries such as Sweden, the United States, and Japan, timber modular housing has become mainstream due to its scalability and environmental compatibility (Ferdous et al., 2019; Bello et al., 2023).

Despite these advancements, Nigeria has not significantly explored or adopted timber modular housing (IPC, 2024; Oluwunmi, 2024). The few attempts at modular housing have largely relied on imported technologies without due consideration for local capacity, input resources, or environmental suitability (Sholanke et al., 2019; Coskun, 2024). Studies by Ali et al. (2023) and Bello et al. (2023) note a lack of standardization, insufficient technical capacity, and limited investment as major constraints to the adoption of modular technologies in Nigeria's construction sector. While global studies support timber modular construction's efficacy, the suitability of this approach in the Nigerian context, technologically and economically, remains underexplored (Adenikinju, 2019; Bello et al., 2023; Oluwunmi, 2024). Specifically, there is inadequate empirical data on the technological specifications required for timber modular development in Nigeria, the availability and strength of input resources (e.g., timber supply chains, equipment, and trained

manpower), and the financial viability of such initiatives using localized economic indicators (Adenikinju, 2019; Bello et al., 2023; Oluwunmi, 2024). The challenge is not only exacerbated by the lack of a well-defined implementation framework for modular housing delivery in Nigeria, stakeholders – including government agencies, private developers, and construction professionals – possess limited knowledge on how to effectively identify, adopt, and scale the use of modular timber technology (Sholanke et al., 2019; Nzube, 2022; Adeyemi et al., 2023). Additionally, while studies have been conducted on prefabricated building systems, few have systematically assessed timber-based systems in terms of engineering economy and investment sustainability (Moore, 2019; Siyan et al., 2019; Adedeji et al., 2023; Ogunnaike et al., 2025).

Timber modular housing offers a promising solution to Nigeria's housing crisis, however, there is a significant gap in understanding its technological feasibility and economic viability within the context of Southwestern Nigeria (Oyebode and Daniel, 2024; Fagbohun et al., 2025; Yagboyaju and Ikwuagwu, 2025). Without data-driven insight into input resource availability, firm-level capabilities, and cost-benefit projections, stakeholders cannot make informed investment or policy decisions to support modular housing development (Oyebode and Daniel, 2024; Fagbohun et al., 2025; Yagboyaju and Ikwuagwu, 2025). Consequently, this study explores filling these gaps by assessing firms' investment and operational capabilities in timber modular housing, as well as the technological specifications and economic viability of timber modular housing development in Southwestern Nigeria. By focusing on these objectives, the study establishes key benchmarks to support timber modular housing integration in urban Nigeria, informing policy, investment and development planning decisions.

LITERATURE REVIEW

Modular Timber Housing for Nigeria: Technologies, firm capabilities, and global lessons

Modular construction is a leading global strategy for addressing affordable housing through industrialised, flexible, and sustainable delivery (Khan et al., 2022; Adeyemi et al., 2024; Nascimento, 2025; Zohourian, et al., 2025). Its

success depends not only on technical benefits but on how firms, supply chains, and policies are structured to realise them (Xu et al., 2020; Kamali et al., 2022; Khan et al., 2024; Oyefusi et al., 2024; Nascimento, 2025; Zohourian et al., 2025).

Globally, modular systems use standardized, flexible modules enabled by design-for-manufacture-and-assembly (DfMA), Building Information Modelling (BIM), and digital planning to integrate factory production with on-site assembly (Sholanke, et al., 2019; Ghufuran et al., 2022; Djukanovic et al., 2025; Laovisutthichai & Lu, 2025; Zohourian et al., 2025); while volumetric timber systems support circularity, reuse, and low embodied carbon (Li et al., 2023; Barreca et al., 2022). This approach delivers faster timelines, lower costs, improved quality control, and reduced on-site disruption (Ferdous et al., 2019; Oluwunmi, 2024), while enabling flexible, adaptable, and sustainable designs for both temporary and permanent housing solutions, particularly in high-demand contexts (Ferdous et al., 2019; Ghannad, 2020; Oluwunmi, 2024).

To realise these benefits, firms require technological capabilities in process integration (synchronising design, factory production, logistics, and site assembly for time and cost gains); product and material innovation (e.g. thermally insulated concrete modules); and quality and performance management (meeting structural, thermal, and durability standards at scale) (Ferdous et al., 2019; Barreca et al., 2022; Chourasia et al., 2023; Li et al., 2023; Antunes et al., 2024; Balasbaneh &

Ramadan, 2024; Djukanovic et al., 2025; Laovisutthichai & Lu, 2025; Zohourian et al., 2025).

In countries such as Portugal, China, Singapore, and the US, these capabilities enable industrialised, low-labour, and high-volume affordable housing delivery (Ferdous et al., 2019; Xu et al., 2020; Munmulla et al., 2023; Antunes et al., 2024; Djukanovic et al., 2025; Nascimento, 2025; Nafisat, 2025). In Nigeria, modular construction is emerging as a response to an estimated 28 million housing deficit (Kazeem et al., 2024; Oluwunmi, 2024), offering faster, more affordable, and environmentally efficient housing delivery (Bello et al., 2023; Kazeem et al., 2024; Oluwunmi, 2024). Its success – especially for timber systems – depends on resource availability (raw materials, labour and machinery) and firm technological capability, i.e., the ability to identify, acquire, adapt, and deploy production technologies (Ogundari, 2020).

Global Modular Housing Initiatives and Economic Viability

Table 1 shows examples of global modular housing initiatives and economics across countries such as Brazil, China, India, Europe, North America and Asia. Modular housing is used as a policy-backed tool for affordable housing, often embedded in national or city-level programmes (Xu et al., 2020; Khan et al., 2022; Adeyemi et al., 2024; Antunes et al., 2024; Khan et al., 2024; Nascimento, 2025; Nafisat, 2025).

Table 1: Examples of global modular housing initiatives and economics

Initiative/Context	Main Focus	Economic Insight	Citations
Brazil “Minha Casa Minha Vida”, China, India	Large-scale affordable housing	Cost and time reductions with standardised prefabrication	(Nascimento, 2025; Adeyemi et al., 2024; Khan et al., 2024; Xu et al., 2020)
Portugal, Australia, Canada	Housing and labour shortages	Faster delivery, improved safety, economic viability over project life	(Antunes et al., 2024; Khan et al., 2022; Ferdous et al., 2019; Kamali et al., 2022)
Sri Lanka	Affordable single-storey housing	32% lower total cost, 36% lower labour cost vs. conventional	(Munmulla et al., 2023)
Timber/circular construction (EU, global)	Low-carbon and reusable building stock	Lower embodied energy, potential for module reuse, strong life-cycle performance	(Li et al., 2023; Balasbaneh & Ramadan, 2024; Barreca et al., 2022)

Life-cycle economic assessments show modular homes can perform excellently economically over their lifespan, even when upfront costs are higher, once operations, maintenance, and residual value are included (Munmulla et al., 2023; Balasbaneh & Ramadan, 2024; Kamali et al., 2022). At the same time, high initial investment, transport complexity and financing remain central deterrents, especially in affordable housing (Ferdous et al., 2019; Chourasia et al., 2023; Khan et al., 2024; Nafisat, 2025; Oyefusi et al., 2024).

Global vs Nigerian Perspectives on Modular Housing Utilisation

The global pattern as reported in Ferdous et al. (2019); Xu et al. (2020); Kamali et al. (2022); Khan et al. (2022); Chourasia et al. (2023); Antunes et al. (2024); Khan et al. (2024); Oyefusi et al. (2024); Laovisutthichai & Lu (2025); Nascimento (2025) focus on:

- i. Growing mainstream adoption in affordable housing, social housing, and multi-storey buildings, supported by government incentives, technical guidelines, and maturing industrial supply chains.
- ii. Firms operating as industrial producers, optimising scale, standardisation and logistics, often under strong regularity and policy frameworks.

The Nigerian pattern as reported in Sholanke et al. (2019); Oluwunmi & Coker (2024); Oyefusi et al. (2024) indicates:

- i. High awareness but low adoption of modular construction in affordable housing delivery especially in Lagos, Port Harcourt, Abuja, Kaduna, Maiduguri and other big cities;
- ii. Constrains in implementation by client resistance, limited installation experience, transport challenges, bureaucratic hurdles, and perceptions of inferior quality
- iii. Firm and industry-level capabilities (factory infrastructure, trained modular workforce, logistics systems, standardised design platforms) are still emerging, limiting economies of scale and increasing initial costs relative to global leaders.

Economic considerations – particularly capital intensity and long-term cost savings – are widely identified as both key drivers and constraints to modular housing adoption globally and in Nigeria

(Sholanke et al., 2019; Kamali et al., 2022; Munmulla et al., 2023; Oluwunmi & Coker, 2024; Oyefusi et al., 2024; Nascimento, 2025; Nafisat, 2025). While strong policy support and mature firm capabilities have enabled modular housing to evolve from niche to systemic solutions globally, it remains at experimental/early adoption stage, with fragmented firm capabilities in Nigeria with limited integration into national housing strategies.

Economic Viability of Timber Modular Housing in Nigeria

The economic viability of timber modular housing in Nigeria depends on both its cost performance and the ability of the industry to overcome modular construction barriers. Timber is already shown to be cost-competitive in Nigerian housing construction. Timber suspended floors can be about 21.5% cheaper than reinforced concrete, supporting affordability for low-income groups (Oyedepo & Olanitori, 2021). This material advantage provides a strong basis for timber-based modular systems.

Modular and Modular Integrated Construction (MiC) offer reduced construction time, improved productivity and better quality, all of which can translate into lower life-cycle costs when projects are standardised and scaled (Sholanke et al., 2019; Arowoia & Oyefusi, 2022; Akindeinde et al., 2024).

Nigerian professionals recognise time and cost savings, waste reduction, and sustainability as key benefits of modular methods, indicating positive economic potential for modular timber housing if adopted more widely (Oluwunmi & Coker, 2024; Arowoia & Oyefusi, 2022; Sholanke et al., 2019). International evidence on modular timber shows additional gains from lower embodied energy and greenhouse gas emissions, and potential reuse of modules, which can further improve long-term economic performance and resilience to future carbon-related policies and costs (Li et al., 2023; Gutiérrez et al., 2024; Tenório et al., 2024).

For Nigeria, a robust economic viability assessment of timber modular housing – life cycle cost analysis (LCCA), net present value (NPV), internal rate of return (IRR), and benefit-cost ratio (BCR) – should explicitly reflect:

- i. Full life-cycle costs and benefits (LLCA): including capital, production, logistics,

- installation, operation, maintenance, replacement, and end-of-life or reuse value
- ii. Time and productivity effects: cost and revenue implications of reduced construction duration, faster occupancy, and improved labour efficiency.
- iii. Capital intensity and financing conditions: high upfront factory and technology costs, cost of capital, and access to credit.
- iv. Local supply chain and scalability realities: timber availability, infrastructure constraints, import dependence, and economies of scale effects.
- v. Technological capability and risk factors: firm capacity to deploy relevant technologies alongside risks such as inflation, policy instability, and market acceptance.

(Sholanke et al., 2019; Barreca et al., 2022; Kamali et al., 2022; Li et al., 2023; Munmulla et al., 2023; Oluwunmi & Coker, 2024; Oyefusi et al., 2024; Nafisat, 2025)

These financial indicators provide a comprehensive view of costs and benefits over the lifespan of the housing units (Sullivan et al., 2000; Towler and Sinnot, 2013). Life cycle costing, in particular, extends beyond initial capital costs to include operation, maintenance, and end-of-life costs (Ghufran et al., 2022; Nzube, 2022). This holistic view is vital for comparing modular construction with conventional housing approaches. Cost components typically analyzed include:

- a. Capital investment
- b. Construction and installation
- c. Operational costs
- d. Maintenance and repairs
- e. Depreciation and salvage value

Pan and Sidwell (2011) report that modular construction methods often outperform traditional approaches in terms of cost-effectiveness over time, particularly when standardization and bulk production are achieved. However, initial costs may be higher, especially where modular supply chains and infrastructure are underdeveloped.

METHODOLOGY

The study design was descriptive and exploratory. A mixed-methods approach was adopted combining both quantitative and qualitative methods to achieve a comprehensive understanding

of modular housing development in Southwestern Nigeria. The study focused on 3 States (Oyo, Ogun and Lagos) out of the 6 States in the region, due their severe housing deficits and concentration of building and engineering firms. An infrastructure planning framework was used. A structured copy of questionnaire was used to gather data from 5 housing/infrastructure ministry officials as well as 5 private-sector built-environment construction & engineering professionals from each state, in the study area. Technology specification data for modular housing development obtained included housing type (duplex/triplex, semi-detached, detached and town houses), housing dimensions (measured in feet), the total number of these housing types and their total estate area across the study area. The engineering economy analysis data included capital expenditure (cost of land, construction work, infrastructure and interior and site preparation), annual operational expenditure (costs of labour, energy, maintenance and insurance), annual revenue, project lifespan, and minimum annual rate of return). The data obtained were analyzed using descriptive statistics and engineering economy methods.

RESULTS AND DISCUSSION

This section presents the results and discussion of the present study.

Technographic characteristics of the modular housing industry

The study revealed that Partnerships (45%) and Limited Liability companies (42.2%) dominate the firms in the modular housing industry in Southwestern Nigeria (Table 2). About 93% of these firms have between 6 – 35 years of experience, while 37.5% have 26 – 35 years of experience. Furthermore, about 63% of the firms are medium-scale companies. Thirty-five percent of the firms sampled initiated their businesses with start-up capital of between N 5-10 million, while 32.5% started with N 10-15 million and 20% with N 15-20 million. This indicates that modular housing investment is not a high-end business operation as N 5-20 million is still relatively affordable.

The table further indicated that investment capital was primarily sourced through personal savings of the business owners (45.0%) while banks (35%)

Table 2: Technographic Characteristics of the Firms in the Modular Housing Industry

No.	Parameters	Respondents	
		Frequency	Percentage
1.	Ownership structure		
	Sole proprietorship	9	7.5
	Partnership	54	45.0
	Cooperative society	-	-
	Limited liability	51	42.5
	Family business	-	-
	Government	6	5.0
	Total	120	100.0
2.	Years of experience		
	< 5	6	5.0
	6 – 15	36	30.0
	16 – 25	30	25.0
	26 – 35	45	37.5
	> 36	3	2.5
	Total	120	100.0
3.	Size of the firm		
	Small	6	5.0
	Medium	75	62.5
	Large	39	32.5
	Total	120	100.0
4.	Initial startup capital (N)		
	< 1,000,000	6	5.0
	5,000,000 – 10,000,000	42	35.0
	10,000,000 – 15,000,000	39	32.5
	15,000,000 – 20,000,000	24	20.0
	20,000,000 – 25,000,000	3	2.5
	25,000,000 – 30,000,000	3	2.5
	> 30,000,000	3	2.5
	Total	120	100.0
5.	Leading sources of investment capital		
	Personal savings	54	45.0
	Cooperative Society	27	22.5
	Banks	42	35.5

and cooperative societies (22.5%) were the two othermajor sources of financing.

Investigations into the capabilities of firms in modular housing development focused on two key areas: Investment capabilities (Table 3) and Operational Capabilities (Table 4). Results from analysis of investment capabilities of firms in the study area in modular housing development show that the 5 indicators were rated as Low (between 2.00 and 2.48) with overall rating of 2.25 (Low). The Low overall investment capability rating indicates that the industry is limited in its ability to effectively expand into available markets due to its limitations in acquiring necessary manpower and

infrastructure needed to foster market development.

Table 4, which focuses on operational capability of the firms paints a more robust story. Results from this analysis show that 7 key indicators of operational capability were rated between Low to Moderate (2.95 – 3.70), with Overall rating of 3.39 (Moderate). Moderate rating indicates satisfactory technical competences in the operations of timber modular housing development by firms in the study area. This may infer that timber modular housing development may be pursued as a viable option to meet housing deficiencies in the region, and foster robust private housing development.

Table 3: Investment Capability of Firms in Timber Modular Housing Development

S/No.	Description of Ability	Mean Rating
a	Ability to carry out feasibility study in the firm	2.41
b	Ability to recognize or purchase the materials and needed equipment	2.50
c	Ability to recognize, select and purchase advanced needed equipment	2.48
d	Ability to prepare, design and Set up a modern equipped workshop	2.31
e	Ability to recruit standard personnel needed	2.00
Overall Rating		2.25

Key: 5-point Linkert scale: 1 – Very Low; 2 – Low; 3 – Moderate; 4 – High; 5 – Very High

Table 4: Operational Capability on Timber Modular Housing Development

S/No.	Parameters	Mean Rating
a	Ability to execute quality assurance in building	2.95
b	Ability to trouble shooting	3.40
c	Ability to develop strategies for cost saving	3.48
d	Ability to execute inventory control	3.70
e	Ability to improve on operational process	3.28
f	Ability to improve on existing modular structure	3.20
g	Ability to introduce new modular designs	3.58
h	Ability to implement planning and development decisions	3.55
Overall Rating		3.39

Key: 5-point Linkert scale: 1 – Very Low; 2 – Low; 3 – Moderate; 4 – High; 5 – Very High

Technological Specifications for Timber Modular Housing Development in Southwestern Nigeria

Table 5 indicates the technical specification preferences for different standardized sizes in timber modular housing development. The most common dimension for duplex/triplex units is 60 x 120 ft (47.5%), followed by 120 x 120 ft (30%). For semi-detached houses, the dominant dimensions were 120 x 120 ft (35%) and 60 x 120 ft (22.5). Predominant sizes for detached houses were 120 x 120 ft dimensions (50%) and 60 x 120 ft dimensions (37.5%). Townhouses tend toward larger dimensions with 55% of them exceeding 120 x 120 ft, while 37.5% of them being 60 x 120 ft. The Estate areas for these units show that larger land footprints (>14,911 m²) are more commonly associated with duplex/triplex and detached units, possibly to accommodate layout and prefabrication logistics. These findings indicate that timber

modular housing development in the study area predominantly utilizes large housing footprints, affirming technological feasibility in adapting timber to varied modular housing configurations.

Engineering Economic Analysis for the Construction of Timber Modular Housing Development in Southwestern Nigeria

The results indicate total capital expenditure (CAPEX) and annual operating costs (OPEX) of N 213.12 and 0.996 million respectively. The annual revenues from house leasing was estimated at N 2.4 million (See Table 6). The economic viability analysis, using a minimum attractive rate of return (MARR) of 20 % showed that the project was viable with Present Worth (PW) and Annual Worth (AW) of N 220.1 and 265.5 million respectively. This indicated that the timber modular housing development in Southwestern Nigeria was viable and worthwhile for the investment.

Table 5: Technical Specification for Timber Modular Housing Development

Housing Type	Dimension (ft)	Number	Percentage (%)
Duplex/Triplex	60 x 60	0	0.0
	60 x 120	57	47.5
	120 x 120	36	30.0
	120 x 120 above	27	22.5
	Total	120	100.0
Semi-detached	60 x 60	24	20.0
	60 x 120	27	22.5
	120 x 120	42	35.0
	120 x 120 above	27	22.5
	Total	120	100.0
Detached House	60 x 60	12	10.0
	60 x 120	45	37.5
	120 x 120	60	50.0
	120 x 120 above	3	2.5
Town House	60 x 60	0	0.0
	60 x 120	45	37.5
	120 x 120	9	7.5
	120 x 120 above	66	55.0
Duplex/Triplex	Total	120	100.0
	450	0	0.0
	550	18	15.0
	900	9	7.5
	14,911	36	30.0
	> 15,000	57	47.5
Semi-detached	Total	120	100.0
	450	18	15.0
	550	3	2.5
	900	6	5.0
	14,911	60	50.0
	> 15,000	33	27.5
Detached House	Total	120	100.0
	450	18	15.0
	550	9	7.5
	900	33	27.5
	14,911	57	47.5
	> 15,000	3	2.5
Town House	Total	120	100.0
	450	6	5.0
	550	51	42.5
	900	12	10.0
	14,911	9	7.5
	> 15,000	42	35.0
Total	120	100.0	

Table 6: Engineering Economic Analysis for the Construction of Timber Modular Housing Development in Southwestern Nigeria

S/No.	Description of Item	Amount (N)
A. Investment		
(i)	Cost of land	50,000,000.00
(ii)	Cost of construction work	143,336,200.00
(iii)	Cost of infrastructure and interior	12,285,870.00
(iv)	Cost of site preparation	7,500,000.00
	Sub-Total	213,122,070.00
B. Annual Operating Costs		
(i)	Labour cost	785,000.00
(ii)	Energy cost	55,000.00
(iii)	Maintenance cost	40,000.00
(iv)	Insurance cost	15,500.00
	Sub-Total	995,500.00
C. Annual Revenue		
(i)	Lease/Rent of house	2,400,000.00
(ii)	Salvage value	50,000,000.00
	Sub-Total	52,400,000.00
D. MARR = 20%		
E. Life of the project = 20 years		
F. Profitability Index		
(i)	Present Worth (PW)	220,091,080.50
(ii)	Annual Worth (AW)	265,530,328.80

CONCLUSION AND RECOMMENDATIONS

This study set out to assess the investment and operational capabilities, technological specifications, and economic viability of timber modular housing development in Southwestern Nigeria. The findings confirmed that timber modular construction is a technologically feasible alternative, with firms demonstrating Low Investment capabilities but Moderate Operational capabilities. The study also established that firms were predominantly partnerships or Limited Liability companies, while their initial start-up capital came primarily from personal savings, cooperatives and bank loans. Technical specification analysis highlighted that 120 x 120 ft could be assumed as the standard size for the timber modular houses, while the economic viability analysis indicated that timber modular housing offered a cost-effective construction option, particularly for medium-rise residential buildings. As such, timber modular housing is not only viable but also strategically positioned to mitigate the growing housing deficit in densely populated areas of Southwestern Nigeria.

Based on the objectives and findings of this study, the following recommendations are proposed:

- (i) Scale-up investment in modular housing: Government and private investors should prioritize funding for modular timber housing projects, especially in States with severe housing deficits. Public-private partnerships should be encouraged to leverage shared resources and risks.
- (ii) Develop and upgrade technical capabilities: Construction and real estate firms should be supported with training, access to modern tools, and technical know-how to enhance their capabilities in modular construction technologies, including prefabrication, assembly, and quality assurance processes.
- (iii) Policy and regulatory frameworks: Government should formulate clear policies that support modular construction, including land use regulations, incentives for modular housing developers, and streamlined approval processes for modular projects.

- (iv) Job creation and skill development: Modular housing construction can serve as a catalyst for employment generation. Government should create vocational and technical programs to train artisans, engineers, and project managers in modular construction processes.

By implementing these targeted strategies, timber modular housing can emerge as a transformative solution to housing challenges in Nigeria, fulfilling both technological feasibility and economic viability, as demonstrated in this study.

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