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Modular Housing: Is it a Catholicon for the Housing Stock Deficit in Lagos, Nigeria?

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Abstract

Modular homes appear to be a promising housing option that keeps pace with the rapid rate of urbanisation, especially in growing cities like Lagos. Consequently, this study investigates how professionals in the built environment perceive modular homes, with an emphasis on how they could be a potential solution to the deficit of housing in Lagos State, Nigeria. The primary goals are to navigate the multifaceted aspects of modular housing, examine its merits, identify barriers to its adoption, and gauge its feasibility in the Nigerian context. To achieve these, 200 questionnaires were disseminated among professionals in the built environment in Lagos, and 147 (73.5%) were returned. Descriptive and inferential statistics were used for data analysis. Key findings revealed that modular housing, due to its rapid construction timelines, is a time-efficient solution. However, concerns about initial investment costs and design flexibility emerged as potential barriers to adoption. There is also a clear acknowledgement of the environmental benefits of modular housing, with reduced construction waste indicating its sustainability. Factor analysis is pivotal for revealing deeper insights. For instance, respondents' lack of in-depth knowledge about modular housing was a primary barrier, accounting for 62.67% of the variance. Similarly, advocacy for modular housing was seen as a significant strategy for its adoption, with 52.38% variability. However, challenges remain. A predominant belief among respondents is that modular homes might be inferior in quality to homes built using traditional construction methods. Furthermore, bureaucratic hurdles in obtaining permits could deter investors and developers from undertaking modular housing projects. In conclusion, although modular housing offers a beacon of hope for solving mass housing problems in burgeoning cities like Lagos, clear challenges remain. This study recommends more vigorous advocacy efforts, targeted government intervention, and robust public-private partnerships.

Keywords: Built environment, construction, feasibility, modular housing, mass housing

■1.0 INTRODUCTION

A report by Olujinmi (2024) revealed that Lagos, Nigeria's economic hub and thriving metropolis, is confronted with the formidable challenge of a housing shortage of over 2 million units. This shortfall is not static; rather, it, continues to grow because of the city's rapid urbanisation, population expansion, and consequent rising need for mass housing. The repercussions of this housing shortage (widespread overcrowding and the emergence of slums) disproportionately affect the urban poor and middle-income earners (Iwuagwu and Iwuagwu, 2015).

Traditionally, housing construction in Lagos, like in many parts of the developing world, relies on on-site construction using mortar and brick or block. Although familiar, this conventional method has proved ineffective and inefficient in addressing the housing crisis because of its high costs, lengthy construction periods, and significant resource wastage (Olotuah, 2012). This situation calls for a paradigm shift in housing construction approaches, with modular housing as a potentially viable alternative. Modular housing, as defined by Lawson, et al. (2014), involves the use of prefabricated, customisable, and easily transportable components, which are assembled on-site.

Modular housing offers several advantages over traditional construction methods. Notably, it allows for significant reductions in construction time, as the modules can be manufactured in parallel with site preparation. It also offers cost-efficiency, because economies of scale can be achieved during mass production of modules. Furthermore, environmental sustainability is enhanced as less construction waste is produced, and energy efficiency is often a design feature of the modules. Finally, a controlled factory environment ensures improved quality control and adherence to standards (Sholanke et al., 2019; Wylie, 2023).

The adoption of modular housing has gained traction in regions like Europe, North America and Asia, offering a practical solution to housing shortages and a shift to more sustainable construction practices (Pan, et al., 2012). However, despite its potential, the adoption of modular housing in Lagos, Nigeria and indeed in many developing countries, has been slow and limited. This limited adoption is attributed to a lack of awareness about modular housing, inadequate technical expertise for its deployment, and regulatory constraints that may not favour such an innovative construction method (Olotuah, 2002; 2009). Additionally, the unique socio-economic and cultural context of Lagos may present distinct challenges and opportunities for modular housing that are currently not well understood.

This may be because there is a significant knowledge gap regarding the feasibility, potential benefits, and challenges of adopting modular housing in both developed and developing nations (Arowoiya & Oyefusi, 2022; Thurairajah et al., 2023). Although there are a few research efforts on the issue (Musa et al., 2016; Sholanke et al., 2019; Wuni et al., 2019; Sun et al., 2020; Akinradewo et al., 2021; Arowoiya & Oyefusi, 2022; Ali et al., 2023; Bello et al., 2023), there is still a need for a comprehensive study, particularly in Nigeria, to address this gap and provide valuable insights for policymakers, stakeholders and researchers; and potentially contribute to the development and implementation of effective strategies to alleviate the housing crisis in Lagos. By adopting modular construction, Lagos can not only address the housing deficit but also foster a more sustainable and environmentally friendly construction industry. The use of pre-fabricated modules manufactured in a controlled environment promises better quality control, reducing the likelihood of substandard buildings. This factor is particularly important in a region like Lagos, which has experienced multiple incidents of building collapse due to poor construction practices (Imafidon and Ogbu, 2020). In addition, the massive housing deficit, coupled with the limitations of traditional construction methods, calls for an urgent exploration of alternative solutions; this study examines one such alternative.

Therefore, this treatise will contribute to the broader discourse on sustainable mass housing solutions in rapidly urbanising cities in developing countries. Also, it will provide insights into the feasibility of modular housing in Lagos, considering its unique challenges and opportunities. By fostering a deeper understanding of the potential benefits and barriers to the adoption of modular housing, this research could be useful for other rapidly urbanising cities in developing countries facing similar housing challenges; thereby contributing to the broader global effort to ensure affordable and decent housing for all. Additionally, this study will increase public awareness of the significance of developing sustainable cities and communities (SDG 11).

This research was guided by three key research questions. These are:

1. What are the perceptions of built environment professionals regarding the benefits of modular housing?
2. How feasible is modular housing as a means of closing the housing stock deficit (via mass housing schemes) in Lagos?
3. What barriers, if any, are there to the adoption of modular housing in Lagos?

2.0 LITERATURE REVIEW

2.1 Concept of Modular Housing

Modular housing, also known as prefabricated or off-site construction, has gained attention in recent years as a potential solution to various housing issues, including the urgent need for plentiful, affordable housing in developing countries like Nigeria. As a modern construction approach, modular housing involves the fabrication of individual sections ("modules") in a factory, subsequent transport to a site, and assembly on-site to erect a structure (Hulse et al., 2014).

Modular construction can be categorised into volumetric and non-volumetric systems. Volumetric systems involve the assembly of three-dimensional units in a factory, including interior and exterior finishes, fixtures, and fittings. Non-volumetric systems, on the other hand, involve off-site production of structural components such as panels and frames (Gibb, 2001). Both systems allow for a high degree of customisation to meet specific design and functional requirements.

The modular construction method offers several advantages over traditional construction methods. It is often associated with increased efficiency and shorter construction times because of the ability to perform outmanufacturing and site work concurrently (Smith, 2010). In addition, factory-based production allows for better control over construction processes, leading to higher quality and waste reduction (Nadeem, 2023).

It is noteworthy that this approach (modular housing) transcends the simplistic assembly of prefabricated components. It represents an integrated design and construction approach in which efficiency, precision, and sustainability are pivotal (Arowoiya & Oyefusi, 2022).

The modular construction concept is not entirely new to the construction industry, but it is gaining renewed attention, especially in the context of developing countries like Nigeria. Rapid urbanisation coupled with a fast-growing population has resulted in a significant housing deficit in Nigeria, with demand far outstripping supply (Ademiluyi & Raji, 2008). Coupled with issues of affordability, quality, and sustainability, the housing problem has prompted a renewed search for innovative solutions; one such solution is modular housing.

Given the housing challenges in Nigeria, modular housing presents a promising alternative to traditional construction methods. It offers a faster, more efficient way to deliver quality housing at scale, addressing both the quantity and quality aspects of housing deficits. However, the adoption of modular housing in Nigeria is currently limited. Among the key issues to be addressed is the high initial cost of factory construction, the need for skilled labour, and the lack of regulatory frameworks to support off-site construction.

Modular housing is intrinsically flexible, with modules designed to be versatile and easily adaptable to various layouts. Homes can be single-storey or multi-storey, with options for expansion and alteration over time. This adaptability makes modular housing a suitable solution for several housing needs, from low-cost mass housing to high-end custom-designed residences (Moayedi, 2022).

Furthermore, the utilisation of digital technology plays a significant role in the advancement of modular construction. Building Information Modelling (BIM), for instance, enhances the design, production and assembly of modules, resulting in interoperability and error reduction (Aranda-Mena et al., 2009). These technological advancements can be particularly beneficial in a developing country context like Nigeria, where efficient resource utilisation is crucial for tackling the huge housing deficit.

In the Nigerian context, the modular housing approach aligns with the government's vision of providing affordable and decent housing for its growing population. However, it requires considerable adaptation to local conditions, such as climate, culture, and readily available building materials. Studies suggest that the successful implementation of modular construction in developing countries relies heavily on the adaptation of designs and construction techniques to local conditions, the establishment of local production facilities, and the development of an appropriately skilled workforce (Jaillon & Poon, 2008).

Overall, the concept of modular housing offers a refreshing and potentially transformative perspective on tackling housing crises, like the one in Lagos, Nigeria. As a rapidly developing country with pressing housing needs, Nigeria as a whole stands to gain significantly from adopting and adapting this innovative construction approach. However, this requires an ecosystem approach involving various stakeholders, including government, built environment professionals, academia, and the community, each playing their part in promoting and implementing modular housing.

2.2 Design Considerations for Modular Housing

Modular housing, due to its inherent flexibility, presents an array of design possibilities, leading to homes that are not just cost-effective and quick to build, but also sustainable and aesthetically pleasing. Nevertheless, designing modular homes involves certain considerations that are unique to the modular construction methodology. The design of modular homes must be executed within the limitations of the local transportation system, considering the dimensions of the modules that can be transported on public roads and the restrictions posed by bridges, tunnels, and power lines (Pan et al., 2007). Design standardisation is another critical aspect. Standardisation allows for economies of scale in module production and assembly, thereby reducing costs and construction time. However, standardisation does not mean monotony; modular homes can be customised through a variety of external finishes, roof styles, window placements and internal layouts (Kieran & Timberlake, 2004).

Design for manufacturability is a key concept in modular construction. It entails designing components for ease of manufacture and assembly, considering factors like the manufacturing process, materials and labour skills (Smith & Hobday, 2001). Environmental sustainability is also a fundamental consideration in modular home design. This includes aspects like energy efficiency, choice of sustainable materials, waste minimisation, and the potential for deconstruction and recycling at the end of a building's life (Gorgolewski, 2008).

Specific to Nigeria, additional design considerations need to be taken into account. The designs must respect the cultural and social norms of the local population, ensuring the homes are not only physically comfortable but also culturally appropriate (Opoko & Oluwatayo, 2014). Climate responsiveness is another crucial aspect in the Nigerian context. The design must suit the tropical climate of Nigeria, with appropriate features for natural ventilation, shading, and rainwater harvesting (Ilesanmi, 2010). Local availability of materials is another significant consideration in Nigeria. Given the country's rich natural resources, incorporating locally available materials would support the local economy, reduce transportation emissions, and ensure that buildings are suited to the local climate and conditions (Opoko & Oluwatayo, 2014).

The successful design of modular homes encompasses various factors that, while holding for traditional construction methods, are particularly important in the context of modular construction. Space optimisation is a significant factor in the design process, considering the relatively confined parameters within which modular construction operates (Lawson et al., 2014). To achieve maximum utility and aesthetic appeal, careful consideration must be given to the efficient use of space within individual modules. The incorporation of flexible and multi-functional spaces, storage solutions, and thoughtful layout planning are ways designers can maximise the usability of space within modular homes.

Material selection is another design consideration that warrants particular attention (Gibb, 2001). The materials must not only be suitable for factory production and transportation but should also contribute to the overall performance and aesthetics of the finished structure. For instance, lightweight materials are typically favoured in modular construction because of their ease of transport and assembly. Furthermore, the selection of materials that are durable, easy to maintain, and resistant to local weather conditions is also of paramount importance (Hořínková, 2021).

Inclusive design is an approach that seeks to create environments that meet the needs of all users, regardless of their age, size, ability, or disability (Imrie & Hall, 2001). The adoption of inclusive design principles in modular housing can result in homes that are accessible and comfortable for all residents. This includes considerations like barrier-free access, adequate space for manoeuvring, adaptable layouts, and easy-to-use fixtures and fittings. Additionally, given the pressing housing needs in urban areas of Nigeria, there may be instances where multi-storey modular buildings are proposed to make efficient use of limited land. In such scenarios, structural integrity is a critical consideration to ensure that the assembled modules can withstand the vertical loads and lateral forces due to wind or seismic activity (Hosseini et al., 2016).

Lastly, an essential factor for the successful uptake of modular housing in Nigeria would be the engagement of local communities and other stakeholders in the design process. Participatory design, in which future users and other stakeholders are involved in the decision-making process, can ensure that the final design is relevant to the users' needs and preferences and is, therefore, more likely to be accepted and successful (Sanoff, 2000).

By understanding and addressing these design considerations, it is possible to develop modular housing solutions that are not only time-saving, cost-effective and sustainable but also attractive, comfortable, culturally appropriate and well-received by local communities.

2.3 Benefits of and Barriers to Modular Homes

Some of the benefits of modular homes identified in earlier studies include time savings (Sholanke et al., 2019; Rishi, 2023), improved quality control (Hořínková, 2021; Rishi, 2023), resilience to climate change (Lawson et al., 2014), reduced cost (Sholanke et al., 2019; Nzube, 2022; Subramanya et al., 2020; Rishi, 2023), waste reduction (Musa et al., 2016; Sholanke et al., 2019; Hořínková, 2021; Rishi, 2023) and reduced noise and dust on site (Hořínková, 2021; Rishi, 2023).

Modular housing is not without its challenges. Some of the major barriers to its adoption are regulatory requirements (Razkenari et al., 2020; Rishi, 2023), high initial costs (Rahman, 2014; Razkenari et al., 2020), lack of hoisting capacity to install modules on-site (Wuni et al., 2020), lack of expertise in managing modular housing projects (Pervez et al., 2022), clients reservations (Azhar et al., 2013), lack of suppliers (Azhar et al., 2013; Pervez et al., 2022), and decreased flexibility for design changes (Azhar et al., 2013; Pervez et al., 2022), among others. Despite these challenges, authors have affirmed that modular construction is a viable and increasingly popular option for building homes. Its efficiency, cost-effectiveness, and environmental benefits make it an attractive choice for both home builders and buyers (Rishi, 2023).

2.4 Summary of Relevant Empirical Reviews

This section presents earlier research on issues relating to modular housing and construction in both developed and developing nations. Table 1 summarises some empirical reviews that are germane to this research.

Table 1 Summary of relevant empirical reviews

S/N	Country	Author/Year	Aim	Major Finding(s)
1	Australia	Thai et al. (2020)	To present a critical review of recent innovations in modular construction technology for high-rise buildings with an emphasis on structural systems, joining techniques, progressive collapse and structural robustness.	The researchers stressed that although most of the success stories of adopting modular construction technologies are linked to low-rise buildings, the benefits of modular construction can be maximised in high-rise buildings. The paper highlighted the technical challenges that hinder the widespread adoption of modular construction and proposed potential solutions for future research.
2	USA	Razkenari et al. (2020)	To investigate the industry perspective regarding the adoption of offsite strategies and provide an understanding of the development of the offsite construction industry over time	Findings showed that the greatest barriers were the lack of contractor experience, the inflexibility in allowing design changes, and the lack of familiarity with, and/or knowledge of, offsite practices. Improving design practices to accommodate modularisation, improving the balance of demand against production, and further integrating Building Information Modelling into the industry were selected as the most important factors for improving the offsite construction sector.
3	Hong Kong	Wuni et al. (2020)	To assess risk management in modular integrated construction (MiC) projects	Identified 32 risks associated with MiC projects and proposed a risk management framework
4	China	Ghannad et al. (2020)	To evaluate the potential and feasibility of the prefabricated/modular construction approach for post-disaster recovery.	Prefabricated/modular construction can improve the time efficiency of post-disaster reconstruction due to reduced demand for on-site labour and resources, shorter schedules, reduced site congestion, and improved labour conditions.
5	UK	Ofori-Kuragu and Hill (2021)	To investigate the potential for using modular homes to ease the housing crisis in the UK.	The results suggest that modular construction will result in quicker, less expensive, and more environmentally friendly homes.
6	Czech Republic	Hořínková (2021)	To provide an overview of the advantages and disadvantages of modular construction, including environmental impact.	Modular construction offers advantages in terms of quality, economy, time, and eco-friendliness; but faces challenges like complicated transportation of modules, demanding coordination of production and construction schedules, and the requirement for detailed construction planning.
7	Britain	Thirunavukkarasu et al. (2021)	To develop a Modular Building System (MBS) using built-up sections for better sustainability performance.	The Built-up sections can improve the flexural capacities in modular construction, enhancing its sustainability performance.
8	Nigeria	Nzube (2022)	To conduct survey-based research to establish whether modular housing projects can mitigate the housing crisis in Lagos from the point of view of residents of Dolphin Estate.	63.9% of respondents agreed that modular housing would reduce the housing crisis in Lagos and 67% agreed that it would create conducive, affordable homes for low-income earners.
9	Portugal	Ribeiro et al. (2022)	To investigate the main barriers to the adoption of modular construction in Portugal.	The analyses show that the main barriers are low levels of R&D, a lack of accredited organisations to certify the quality of the manufactured components and the industry's unwillingness to innovate.

Table 1 Summary of relevant empirical reviews

S/N	Country	Author/Year	Aim	Major Finding(s)
10	USA	Abdul-Nabi et al. (2022)	To carry out a comparison between industry practice and literature as related to the prioritisation of project factors affecting the use of modular construction	The results showed a significant difference between the literature and the industry perception of the importance of the 50 identified project factors affecting the use of modular construction.
11	Canada	Kamali et al. (2022)	To propose a framework for benchmarking economic sustainability in the life-cycle of single-family modular homes.	The proposed framework can aid improved selection of construction methods, and identify underperforming areas in the life-cycle of a modular building.
12	Germany	Schnel (2022)	To elucidate the concept of sustainability in the life cycle of modular construction and to illustrate the potential for sustainability in different types of modularisations.	The more detailed the prefabrication of a module, the higher the potential for sustainability. Different stakeholders can exert varying degrees of influence over the sustainability of different life cycle phases of a building.
13	Nigeria	Awodele et al. (2023)	To assess the inhibitors to the use of Building Information Modelling (BIM) in driving modular construction project delivery in Nigeria.	The high cost of investment in hardware and software, resistance to change, lack of management support, BIM software complexity, stakeholders' lack of interest in sharing information, and collaboration problems are some factors inhibiting the adoption of BIM.
14	Pakistan	Pervez et al. (2022)	To perform a comprehensive risk assessment of critical risk factors that negatively impact the implementation of modular construction.	'Inadequate skills and experience in modular construction', 'Inadequate capacity of manufacturers' and 'Inability to make changes in design during the construction stage' emerged as the top three critical risks in the implementation of modular construction.
15	Portugal	Ishirugi (2023)	To evaluate ways to maximise the potential benefits of modular construction and mitigate possible obstacles and interferences	The study emphasised that the advantages of modular construction can be more significant when deployed in the construction of multiple, medium-sized, and repetitive or cellular buildings.
16	Egypt	Ali et al. (2023)	To explore the potential benefits, barriers, and enabling factors of the adoption of modular construction in residential projects in Egypt.	Identified time and cost savings, quality improvement and sustainability as benefits. Barriers included lack of knowledge, resistance to change, and supply chain issues.
17	Nigeria	Ezema et al. (2023)	To examine the concept of circular economy as it affects the built environment and to evaluate the public housing delivery process in Lagos, Nigeria concerning circular principles.	The study established that opportunities exist for massive deployment of circular strategies, but their adoption is low. It recommended more deliberate actions at the design and implementation stages of housing projects to promote a circular economy for the housing sector in urban Nigeria.
18	Australia	Chen (2023)	To investigate the advantages of the modular construction method.	Findings show that the modular construction method can shorten construction time, facilitate collaboration between stakeholders, enable effective management, save labour and costs, reduce waste, and minimise impacts on the local community. The eco-friendly design allows modular buildings to be recycled or relocated for other uses.
19	Hong Kong	Pan and Zhang (2023)	To contribute to a more systematic understanding of modular construction for buildings in urban environments by measuring the sustainability of both concrete and steel modular construction.	Modular construction significantly outperforms conventional practice, with 46%-87% less waste. However, performance varies between steel and concrete modular systems. The study also identified eight system boundaries for dialectical sustainability benchmarking.
20	Nigeria	Bello et al. (2023)	To identify and assess the drivers for the implementation of modular construction systems (MCS) in developing countries.	Results show that 15 of the 16 major drivers (categorised into four groups, namely, management and sustainability, key performance, know-how and logistics, and regulations and policies) were statistically significant towards implementing MCS in developing countries. Moreover, there is a strong relationship among the four categories of drivers.
21	China	Kazeem et al. (2024)	To carry out a systematic review of the integration of building services in modular construction.	The study reveals a mismatch between the theoretical potential of modular building approaches and their real-world implementation, underscoring the necessity for empirical research on life cycle analysis and long-term performance.

3.0 METHODOLOGY

The target population for this study comprised built-environment professionals operating within Lagos State, Nigeria. These professionals, who are central to the construction and management of the built environment, consist of architects, builders, quantity surveyors, and estate surveyors and valuers. Each group in this population provides unique perspectives and insights related to modular construction, making them suitable for this research. At the commencement of this study, a full and exhaustive list of these professionals was not accessible due to data privacy restrictions. Hence, the researchers purposively sampled 200 built-environment professionals (i.e. 50 architects, 50 builders, 50 quantity surveyors and 50 estate surveyors and valuers). This sample size is consistent with Babatunde et al. (2020), who determined that a minimum of 50 respondents from each target group would be acceptable for a study. The primary instrument for data collection was a structured questionnaire. The questionnaire was considered appropriate for this study as it allows for time-efficient data collection from a large sample size, and it facilitates a standardised approach that ensures all respondents receive the same set of questions (Sekaran & Bougie, 2016). The questionnaire was divided into sections corresponding to the study's research questions. The first section sought to gather demographic data such as a respondent's profession, level of experience, and familiarity with modular construction. In the subsequent sections, the questionnaire featured Likert-scale questions, which allowed respondents to rate their agreement or disagreement with a series of statements on a scale from 1 (strongly disagree) to 5 (strongly agree). This type of question was utilised to explore general knowledge on modular housing, highlight its perceived benefits, assess the feasibility of this solution for mass housing in Lagos, identify barriers to its adoption, and proffer appropriate solutions to the identified challenges. The Likert-scale questions were designed based on relevant literature, ensuring their validity and reliability (Dawes, 2008).

Prior to actual data collection, a pilot study was conducted to test the questionnaire with a small group of professionals from the built environment. This helped identify any ambiguity in the questions, and adjustments were made as necessary. The reliability of the questionnaire was tested using Cronbach's Alpha, a statistical measure used to estimate the consistency of responses to a Likert-type scale (Tavakol & Dennick, 2011). Out of the 200 questionnaires administered, 147 (73.5%) were returned and found useful. To thoroughly analyse the collected data and derive meaningful conclusions, this research implemented a sequential approach involving quantitative data analysis techniques, specifically frequency distribution, percentages, mean score, relative importance index and factor analysis. IBM SPSS was employed to enhance the precision and effectiveness of the analysis.

4.0 RESULTS

4.1 Profile of Respondents

This section presents the general characteristics of the respondents. Questions on profession, gender, age, and years of working experience were asked in this section. The responses are detailed in Table 2.

Table 2 Profile of respondents

S/N	Profile	Sub-headings	Frequency	Percentage
1	Profession	Builders	35	23.8
		Quantity Surveyors	30	20.4
		Architects	39	26.5
		Estate Surveyors and Valuers	43	29.3
2	Gender	Male	105	71.4
		Female	42	28.6
3	Age	20 -30 years	64	43.5
		31 - 40 years	46	31.3
		41 years and above	37	25.2
4	Years of experience	≤ 5years	49	33.3
		6-10years	23	15.6
		11-15years	26	17.7
		≥ 16years	49	33.3

Table 2 showcases the professional background of the 147 respondents. Builders have 35 respondents, making up 23.8% of the total; the Architects have 39 respondents, translating to 26.5%; and Quantity Surveyors have the leanest presence with 30 respondents, contributing 20.4% of the dataset. However, it's the Estate Surveyors and Valuers who stand out with 43 respondents (29.3%). Information on the gender of the respondents shows that 105 identified as male, making up 71.4% of the total; 42 identified as female, which constitutes 28.6% of the sample. The data shows a majority of male respondents in this particular sample. The table also illustrates that the largest age group is 20 to 30 years, with 64 respondents, making up 43.5% of the total. The next age group, 31 to 40 years, comprises 46 respondents or 31.3% of the total. The age group of 41 years and above has 37 respondents, accounting for 25.2% of the total. From the data, it is evident that the majority (74.8%) of respondents are within the age bracket of 20 - 40 years.

Furthermore, from the analysis in Table 2, the majority of respondents (66.6%) have either ≤ 5 years or ≥ 16 years of work experience, indicating that there's an equal representation of respondents at the beginning of their careers and those with extensive experience. Respondents with 6 - 10 years of work experience represent 15.6% of the total, which is the least among the groups. This suggests fewer mid-career professionals among the respondents compared to early and late-career professionals. Those with 11 - 15 years of experience make up 17.7% of the respondents, indicating a moderate representation of professionals who are well into their careers but not yet at the highest levels of experience. Overall, the data provides insight into the varied experience levels of the respondents, with a significant concentration at the extreme ends (early and late-career).

4.2 General Knowledge/Opinion on Modular Homes

This section analyses the questions that were posed to the respondents in order to test their knowledge of and opinion on modular homes. Figures 1 and 2 show the analysis.

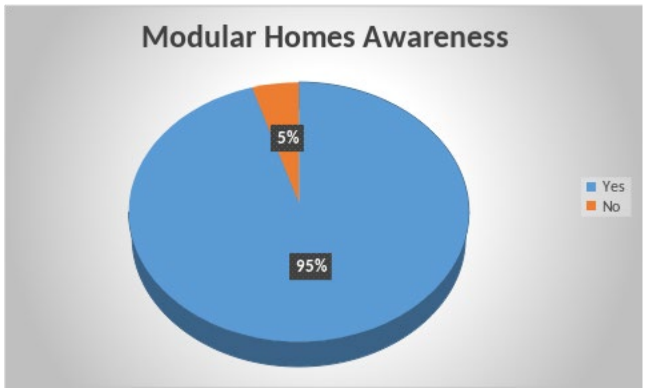

Figure 1 Modular Homes awareness

Figure 1 presents data regarding respondents' awareness of the concept of "Modular Housing". Out of 147 respondents, a significant majority (95%) indicated that they are aware. Only a small fraction of respondents (5%) said they had not heard of modular housing. This indicates that there is a high level of awareness and familiarity with modular housing technology among survey participants.

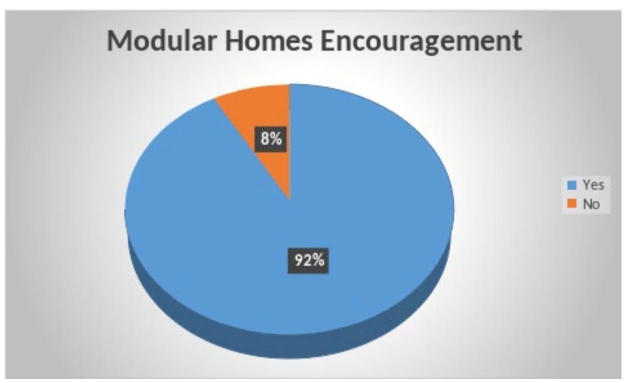

Figure 2 Encouragement of Modular Homes

The data in Figure 2 represents the opinions of the respondents when asked if they would encourage the implementation of modular housing in Lagos. A significant majority, accounting for 92%, expressed their support for modular housing in Lagos; this may suggest that they appreciate its benefits. Conversely, a minority of 8% of respondents indicated that they would not encourage modular housing in Lagos. The reasons behind this could vary, ranging from concerns about its feasibility, costs, or simply a preference for traditional housing methods. Overall, the overwhelmingly positive response suggests that there is a strong interest and acceptance of the concept of modular housing among the surveyed group in Lagos. If the broader populace shares these sentiments, it could pave the way for greater exploration of modular housing in the region.

4.3 Benefits of Modular Homes

For easy interpretation, 5, 4, 3, 2, and 1 were assigned to "Strongly Agree (SA)", "Agree (A)", "Undecided (U)", "Disagree (D)" and "Strongly Disagree (SD)" respectively to ascertain the benefits of modular homes. The mean score and RII were then calculated. Table 3 presents the analysis.

Table 3 Benefits of Modular Housing

Benefits	Mean	RII	Rank
Modular housing construction leads to significant time savings.	4.08	0.816	1st
Modular housing contributes to the reduction of noise and disturbance on construction sites.	3.98	0.796	2nd
The use of modular housing reduces waste generated during construction.	3.94	0.788	3rd
Modular housing is better suited to achieving high energy efficiency standards.	3.92	0.784	4th
Modular housing has a positive impact on overall project scheduling.	3.87	0.774	5th
Modular housing offers improved quality control over conventional on-site construction.	3.85	0.770	6th
The modular housing approach results in a safer construction environment.	3.85	0.770	6th
Modular housing is more cost-effective than traditional construction methods.	3.80	0.760	8th
Modular housing provides more design flexibility than traditional housing.	3.62	0.724	9th

The analysis in Table 3 shows that among the benefits of modular housing, respondents believe most strongly that it leads to significant time savings, with this aspect ranking first and having a mean score of 4.08 and RII of 0.816. Then they acknowledge that modular housing contributes significantly to reducing noise and disturbance on construction sites (ranked second, with a mean of 3.98 and RII of 0.796) and reduces waste during construction (ranked third, with a mean of 3.94 and RII of 0.788). Improved energy efficiency and a positive impact on project scheduling are also recognised benefits, ranking fourth and fifth respectively. On the other hand, design flexibility in modular housing is perceived as the least beneficial, ranking ninth with a mean of 3.62 and RII of 0.724. Overall, the perception of modular housing is predominantly positive, with most of its benefits garnering substantial agreement from respondents.

4.4 Feasibility of Modular Homes for Mass Housing Schemes

In a bid to answer the second research question, the researchers assigned 5 to "Strongly Agree (SA)", 4 to "Agree (A)", 3 = "Undecided (U)", 2 = "Disagree (D)" and 1 = "Strongly Disagree (SD)" respectively to the responses on survey questions about the feasibility of modular homes for mass housing. Then the mean score and RII were calculated. The analysis is provided in Table 4.

Table 4 Feasibility of Modular Homes for mass housing schemes

Statement	Mean	RII	Rank
Pre-Design/Planning Stage			
There is adequate land and space for modular housing on-site.	3.83	0.766	1st
There is adequate space and land for off-site production.	3.78	0.756	2nd
There is a provision for soil testing that will determine the type of design and footings for modular housing.	3.78	0.756	2nd
Raw materials can be easily obtained.	3.62	0.724	4th
Obtaining the required and necessary permits will not be difficult.	3.56	0.712	5th
Average	**3.714**	**0.7428**	
Cost Implication			
Modular housing does not require the logistics of traditional construction, waste of raw materials, labour or environmental conditions that tend to increase the cost of construction.	3.49	0.698	1st
Modular homes are less expensive since there is less waste of raw materials.	3.44	0.688	2nd
Modular housing is the best option for a home that is practical, economical and affordable.	3.38	0.676	3rd
The cost of maintenance of modular houses is lower than that of traditional reinforced concrete houses.	3.37	0.674	4th
The cost of transportation is considerably lower than that of traditional reinforced concrete buildings if the construction site is close to the factory.	3.35	0.670	5th
The cost of future modification of modular housing is lower than that of traditional reinforced concrete structures.	3.26	0.652	6th
Average	**3.382**	**0.676**	
Construction Stage			
The fabrication of modules for modular housing usually takes one to four months.	3.61	0.722	1st
All kinds of risks are minimised at the construction stage in modular housing because the modules are produced in a controlled manner under factory conditions.	3.55	0.710	2nd
Once the modules are available, it takes two to three days to set up a modular home.	3.44	0.688	3rd
Skilled labour and expertise to support the construction of modular housing are available	3.39	0.678	4th
There is availability of local infrastructure (roads, utilities, etc.) to support the construction of modular housing.	3.26	0.652	5th
Modular housing does not require any power tools or large machinery for assembly on-site.	3.10	0.620	6th
Average	**3.39**	**0.678**	
Sales, Leasing & Maintenance			
Compared to traditional reinforced concrete structures, modular housing is easier to maintain.	3.56	0.712	1st
Modular housing can be rented out more quickly than traditional reinforced concrete structures.	3.39	0.678	2nd
Modular houses can sell faster than traditional reinforced concrete buildings because they are less expensive.	3.38	0.676	3rd
Average	**3.44**	**0.689**	

Table 4 Feasibility of modular homes for mass housing schemes

Statement	Mean	RII	Rank
Sustainability			
Modular housing is sustainable because it reduces time, waste, transport impact, energy use, and is recyclable and renewable.	4.01	0.802	1st
The materials for modular housing that would normally be thrown out can easily be recycled; they can be kept at the factory and used for future projects.	3.97	0.794	2nd
Modular houses are often held to higher sustainable standards than regular housing because, at the manufacturing stage, there is a focus on clean and green energy, and usage of non-toxic organic materials.	3.91	0.782	3rd
Average	**3.96**	**0.793**	

The analysis displayed in Table 4, which is on the feasibility of modular homes for mass housing schemes, shows that the top concern during the pre-design/planning stage is the adequacy of land and space for modular housing on-site, with a mean score of 3.83 and RII of 0.766. Following closely is the availability of space for off-site production (of modules) and provision for soil testing, each scoring 3.78 and RII of 0.756. Challenges related to sourcing raw materials and obtaining necessary permits rank fourth and fifth respectively. On issues relating to the cost implication of modular homes in Lagos State, the respondents believe that the primary advantage of modular housing is the simplification of site construction logistics and elimination of waste, which has a mean of 3.49 and RII of 0.698. The economic benefits of being less expensive and the overall affordability of modular housing are the next prominent points; ease of future modification ranked lowest.

The table further shows opinions about the construction stage of modular homes. The fabrication timeline (one to four months) emerged as the top point with a mean score of 3.61 and RII of 0.722. Risk minimisation ranked second. Speed of assembly and the availability of skilled labour and expertise followed while the lowest ranked point was the perceived need for power tools and machinery during assembly. Regarding the sales, leasing and maintenance of modular homes, the respondents are convinced that it is easier to maintain modular homes than traditional structures (mean=3.56; RII=0.712), a potential for faster rental and sales due to cost advantages ranked second (mean=3.39; RII=0.678) and third (mean=3.38; RII=0.676), respectively. Finally, modular homes' sustainability benefits, the possibility of recycling materials, and the heightened sustainable standards at the manufacturing stage followed closely with mean scores of 4.01, 3.97 and 3.91 respectively.

In summary, respondents generally view modular housing as being feasible in terms of land use, sustainability, and simplified construction logistics. Cost issues have the lowest mean value at 3.36; this may indicate a level of concern about modular housing concerning cost.

4.5 Barriers to the Adoption of Modular Housing

To determine the barriers to the adoption of modular housing, 10 items were explored using factor analysis, as shown in Table 5 and Graph 1. Before this, the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy test and Bartlett's Test of Sphericity were utilised to see if the dataset was appropriate for factor analysis. The sampling is said to be adequate if the value of the K.M.O is larger than 0.5 (Field, 2000; Hadia, Abdullaha and Sentosa, 2016). As seen in Table 5 below, the KMO is 0.820, which is more than the recommended threshold of 0.5. As a result, factor analysis was found appropriate for analysing the data.

Table 5 K.M.O. and Bartlett's Test

K.M.O		.820
Bartlett's Test of Sphericity	Approximate Chi-Square	1536.242
	df	45
	Sig.	.000

Table 6 shows that two factors with an eigenvalue larger than one accounted for 78.951% of the aggregate variance.

Table 6 Barriers to the adoption of Modular Homes (Factor Analysis)

Total Variance Explained						
Component	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	Variance %	Cumulative %	Total	Variance %	Cumulative %
There is a lack of knowledge and understanding about modular housing within the construction industry.	6.266	62.665	62.665	6.266	62.665	62.665
The initial costs of modular housing are a significant barrier to its adoption.	1.629	16.286	78.951	1.629	16.286	78.951
The perception of lower quality compared to traditional construction methods hinders the adoption of modular housing.	.601	6.012	84.963			
The lack of flexible design options in modular housing is a deterrent to its adoption.	.436	4.359	89.322			
The construction industry's resistance to change and innovation is a barrier to the adoption of modular housing.	.358	3.584	92.906			
Regulations and building codes pose challenges for the adoption of modular housing.	.302	3.023	95.929			
The potential negative impact on jobs and employment in the traditional construction sector is a barrier to the adoption of modular housing.	.164	1.636	97.565			
The lack of proven performance and long-term durability records discourages the adoption of modular housing.	.115	1.145	98.710			
The limited number of modular housing manufacturers and suppliers in the market hinders its adoption.	.087	.872	99.583			
Limited access to finance for modular housing projects is a barrier to its adoption.	.042	.417	100.000			

Table 6 illustrates the results of a factor analysis on barriers to the adoption of modular homes. The barriers to the adoption of modular homes were analysed in terms of their significance (eigenvalues) and how much variance they explain (as a percentage). The higher the eigenvalue and percentage variance, the more significant the barrier in the context of the entire dataset. According to the analysis, the lack of knowledge and understanding about modular homes within the construction industry is the most prominent barrier, with an eigenvalue of 6.266, explaining 62.665% of the total variance. The initial costs of modular homes ranked second with an eigenvalue of 1.629 and accounts for 16.286% of the variance. Cumulatively, the first two factors account for 78.951% of the variance, indicating that they are the major barriers. In summary, the two most significant barriers to the adoption of modular homes are the industry's lack of knowledge and the initial costs. The other factors, while still relevant, have much lesser weight in the entire range of barriers identified in the dataset.

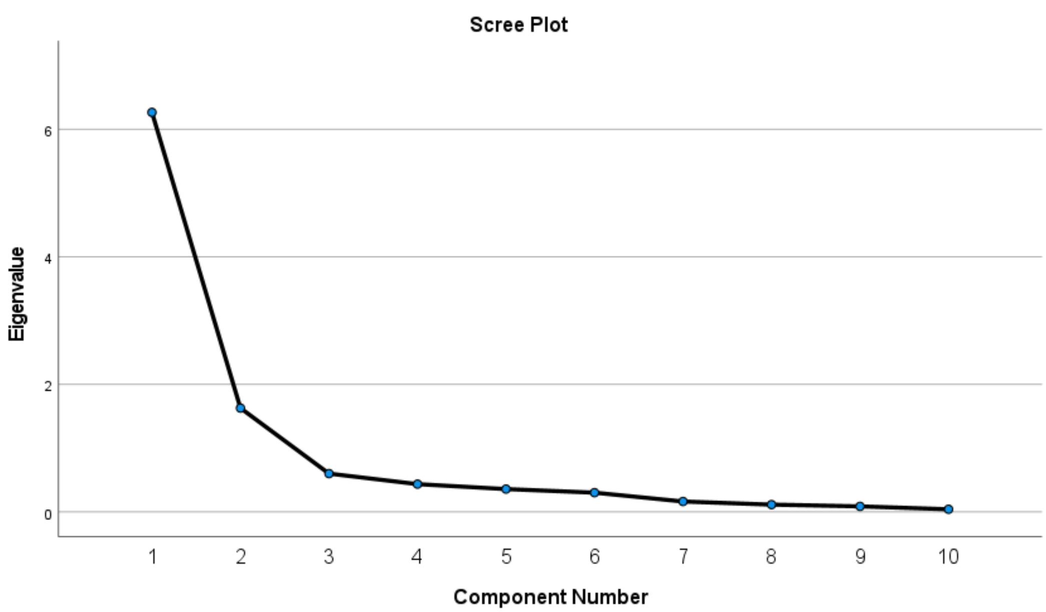

Figure 3 Scree plot: Barriers to the adoption of Modular Homes

The scree plot highlights the first component's dominance with the highest eigenvalue of approximately 6, followed by a sharp drop to the second component. After the third component, the decline stabilises, with components from the sixth onward showing minimal variance contribution. The scree plot implies that the most significant barriers are posed by the first two components. This means that while there are multiple listed barriers, the majority of the variance or differentiation in responses can be attributed to these initial components. In practical terms, the most significant barriers to adopting modular housing will be surmounted by addressing the issues highlighted in the first two components. The remaining barriers have diminished significance and might not be as rewarding to address.

4.6 Measures to Eradicate Barriers

The respondents were asked to choose from a list of measures that may be taken to eradicate barriers to the adoption of modular homes. Their responses were analysed using the Relative Importance Index; the result was interpreted following the suggestion of Fernando (2014). Table 7 provides the analysis.

Table 7 Measures to eradicate barriers

Measures	Mean	RII	Rank
Enlightenment and advocacy for the adoption of modular housing within the construction industry	4.18	0.836	1st
Provision of adequate access to finance	4.07	0.814	2nd
Modular housing designs should have flexible design options	4.06	0.812	3rd
The government should modify the relevant regulations and building codes to accommodate the successful implementation of modular housing	4.01	0.802	4th
The government should encourage the establishment of modular housing components manufacturers (e.g. through tax holidays)	4.00	0.800	5th

Note: *low level = (RII < 50%); medium level = (50% ≥ RII < 70%) and high level = (RII ≥ 70%)*

Table 7 presents measures proposed to address barriers to the adoption of modular housing. The top-ranked measure (RII=0.836) suggests that enlightenment and advocacy are crucial; access to adequate finance comes second with an RII of 0.814. Ranked third is flexible design options (RII=0.812), while the fourth-ranked measure is modification of government regulations (RII=0.802). Ranked last with an RII of 0.800, is government incentivisation of establishment of manufacturers (RII=0.800). In summary, the majority of respondents believe that awareness campaigns, better financing, design flexibility, regulatory adaptations, and government incentives for manufacturers are pivotal measures to eliminate barriers to modular housing adoption.

■5.0 DISCUSSION

From the data gathered on the first research question, it is evident that a significant percentage of respondents agree that modular housing construction leads to substantial time savings, making it the top-ranked benefit with a mean score of 4.08. This aligns with the findings of Rishi (2023), who highlighted the swift construction timelines of modular homes as compared to traditional methods. Furthermore, modular housing's environmental advantages were important, with a mean score of 3.94. These results corroborate the works of Sholanke et al. (2019), Hořínková (2021) and Rishi (2023), which identified decreased material wastage as a pivotal eco-friendly advantage of modular construction. However, while many believe modular housing is cost-effective, this attribute ranked ninth with a mean score of 3.80, indicating a non-unanimous consensus. This discrepancy might stem from the initial high costs of setting up modular construction facilities, as noted by Razkenari et al. (2020).

Furthermore, regarding the analysis of data on the feasibility of modular homes in Lagos, the results were clear. Adequate land and space for on-site construction and off-site production, soil testing provisions, and ease of obtaining raw materials ranked high. However, the responses about obtaining necessary permits (mean of 3.56) reflects the bureaucratic challenges highlighted by the likes of Razkenari et al. (2020) and Rishi (2023). Respondents were affirmative of the feasibility of modular homes in addressing mass housing issues, as indicated by a mean of 3.88. This aligns with findings from Nzube (2022), who discussed the potential of modular homes in bridging housing deficits in developing cities. It is important to note that time efficiency and environmental sustainability are well-documented advantages of modular homes in global studies. However, the non-unanimous consensus on cost-effectiveness, especially in the context of Lagos, offers a unique perspective that might be attributed to challenges – like high startup costs – peculiar to emerging markets.

Additionally, the respondents' opinions on the challenges hindering modular housing adoption in Lagos showed that the leading barrier identified is a lack of knowledge and understanding about modular homes within the construction industry. This finding is consistent with the Cheng et al. (2017) study, which highlighted an information gap in emerging markets about modern construction techniques. Another prominent barrier is the high initial cost of modular homes. This aligns with the observations of Razkenari et al. (2020) and Pervez et al. (2022) which affirmed that high initial investment cost has a detrimental impact on the adoption of modular construction. Finally, the majority of respondents believe that awareness campaigns, easier financing, design flexibility, regulatory adaptations, and government incentives for manufacturers are crucial measures in eliminating constraints to the adoption of modular homes.

■6.0 CONCLUSION AND RECOMMENDATIONS

The urban housing crisis is a pressing challenge, with modular housing emerging as a feasible solution. While its benefits are universally acknowledged, there are barriers to its adoption. For Lagos, the path to realising the full potential of modular housing lies in raising awareness, implementing favourable policies, provision of financial support by government and stakeholder collaboration. As cities across the globe grapple with housing deficits, this research underscores the importance of tailored, localised strategies to drive innovative housing solutions.

The following recommendations are hereby proposed:

1. Awareness and Training: Professional associations in the built environment should implement comprehensive training programs and awareness campaigns to bridge the knowledge gap within their membership.
2. Financial Incentives: Government and financial institutions should introduce subsidies or loan programs to offset initial costs and support the modular housing industry's growth.
3. Regulatory Flexibility: The government should revisit building codes and regulations to be more accommodating of modular housing projects.
4. Stakeholder Collaboration: Federal and state agencies (e.g. Ministry of Housing) should foster collaboration between modular housing manufacturers, real estate developers, and financial institutions to streamline processes and overcome adoption barriers.

This research only covered built environment professionals in Lagos State; a further study which extends to built environment professionals in other geographical locations could be conducted. Finally, this study did not look at the cultural, economic and other factors that might influence modular housing adoption; a follow-up study can look into this.

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