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Preferred Prefab: Examining the Cultural Acceptance of Assembly-Line Homes for Sustainable Housing Delivery in Nigeria

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Abstract

This study takes an exploratory look at the extent to which culture could be integrated with building innovation for the delivery of prefabricated housing solutions in Nigeria. The study methodology utilised a content analysis model of case studying and desk research to review developments in prefabricated housing with the specific objective of proffering sustainable off-site housing models that will not only be climate responsive and affordable, but will also draw inspiration from the cultural and ancestral patterns users can relate to. The study findings show significant ongoing dialogue between design/building innovation and social architecture which imbibe cultural values in a few of case studies. The study also uncovered potential for improved affordability of prefabricated housing using 3D printing techniques and modular installation of housing units crafted from locally sourced or recycled eco-waste. The study recommends widespread experimental testing of alternative building materials and products to further drive prefab housing costs downwards, as well as future collaborations between vernacular architects and building innovators towards practical realisation of sustainable development housing goals. The study also encourages wider empirical studies on the degree of acceptance of prefab housing solutions in countries like Nigeria in a bid to sensitise target users on the potentials of off-site construction.

Keywords: *Prefabrication, Sustainable housing delivery, Vernacular architecture*

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Background to the Study

Housing is universally acknowledged as one of the most basic of all human needs. However, despite significant intervention and concerted efforts, global housing shortages persist at a worrying rate (Ogundeji, 2024). It is estimated that 1.8 billion of the world's population live in less-than-adequate housing, over 150 million persons currently live in some state of permanent homelessness, and some 15 million people live under the threat of eviction annually (Morrison & Stadelmann, 2023; Wormald, 2024). These figures are likely to be exacerbated by the increase in economic, political and social tensions in countries like Ukraine, Gaza, Haiti and Afghanistan over the past 2 years (Morrison, 2023). To overcome this global housing deficit, it is estimated that countries like the USA and the UK need to provide up to 6.5 million and 4.3 million homes per annum, respectively (Morrison & Stadelmann, 2023). The housing deficit in Nigeria stood at over 28 million units as at November 2023 by official figures but so dire is the situation on ground, many housing speculators believe this shortfall is closer to 50 million units (Oshundairo, 2023; Ibem, Aduwo & Ayo-Vaughn, 2015; Olayiwola, Adeleye & Ogunshakin, 2005). The deficit is particularly noticeable among the vulnerable in society such as women (Okafor, 2020) and displaced persons whose rights to land ownership and development have been restricted through normative or disruptive patterns (Adesote & Peters, 2015).

The housing crisis has spurned several discussions about sustainable solutions centred around three main components, being: cost – the need for affordable yet profitable solutions for whom they are intended; climate – adaptive and suitable enough for the planet; and culture – conformity and acceptance for the people who will use them (Ghisleni, 2024). Though several studies effectively lend to the discussions of lowering building cost and climatic needs, there is scant evidence on the cultural features of updated housing needs. Prefabricated housing is often perceived as a culmination of sustainable housing innovation (Wormald, 2024; Steinhardt & Manley, 2016). Cheaper to erect than most comparable in-situ versions, and available in a wide range of eco-friendly compositions, prefabricated solutions have come a long way from the transportable castles and forts of conquerors first documented in the 9th century to modern day buildings with components such as the floors, walls, roofs and services, that are partially or wholly manufactured in a factory or plant and easily assembled on the eventual site (Hearn, 2018). The scope and technology behind prefabricated construction varies significantly from small, single dwelling units (e.g., micro-units, tiny houses, Hex® homes, etc.), to large institutional projects such as hospitals, schools, offices and even religious buildings (Grossmann, 2023; McKnight, 2016). Though sometimes considered transitory housing, prefabricated structures are still mandated to conform to all standard building codes as permanent (or in-situ) buildings (Dave, Watson & Prasad, 2017). This defers to all considerations concerning construction techniques and materials, cost considerations, and the cultural contexts for each of these buildings to be deemed suitable.

This study provides an overview of the prefabricated housing industry as it impacts the provision of affordable housing for the vulnerable in society in developing countries. The paper examines the economic and technical considerations which have led to advances in off-site building, particularly in the housing sector. In order to evaluate the effect of cultural

influences on the development of prefabricated housing solutions, the study seeks to address the following questions: What has been the national response to the introduction of prefabricated housing solutions in Nigeria? How influential are cultural factors in determining the degree of acceptance of prefabricated housing in Nigeria? How can prefabricated homes incorporate the cultural ethos of vernacular architecture that will endear them to address the housing needs of the socially vulnerable in Nigerian society?

Literature Review

Prefabrication is, by no means, a novel concept in the erection of buildings. Earliest records of prefabricated buildings come from nearly a thousand years ago when explorers and conquerors sought out foreign lands with movable garrisons and accommodation. These were neither designed to be permanent or urgent as there was no need to develop them further once a new colony had been established (McKeever, 2024; Kamali & Hewage, 2016). Modern building prefabrication, or simply "prefab" as they more commonly called, has evolved in scope and execution due to growing concerns for building cost efficiency, faster turnaround and, in some cases, reusability (Morrison, 2023). Controlled building environments, the use of mass-produced components, and more recently, the use of 3D printing techniques have contributed to making the production process of prefab more efficient (Dooley, 2024; Williams, 2024; Akeremale, 2020; Azman, Ahamad, & Wan Hussin, 2012). Prefab construction is also doing well to ride on the trends of eco-friendly and sustainable building practices with the development of a variety of materials and construction techniques using materials such as straw, recycled plastic, food waste and by-products, earth, bamboo and so on (Dua, 2024; Thorsby, 2023; Povinelli, 2022; Arkin, 2020; Jain, 2017) as shown in Figure 1. In this way, many prefab models have demonstrated that it is possible to live symbiotically with the environment without clashing with it.

Several studies and reports have hailed modern prefab housing as a much-needed innovation in a sector beleaguered with delivery and performance woes (Zhang, Tan, Shi, Hou & Zhang, 2022). However, despite significant strides and development, the prefab industry is still plagued by inconsistency and challenges (Erlich, 2023; Zairul, 2021; Correia, Simões da Silva, & Murtinho, 2012). The last decade has been specifically hard hit by global recessions which caused a significant decline in the construction industry over low housing demand. This period coincided with the boom in prefab start-ups, many of which were forced to downscale, liquidate or, in some cases, file for bankruptcy following the inability to recoup the losses incurred to high energy costs, interest rates and cost-of-living problems (McKeever, 2024). Another challenge facing the prefab industry is the imbalance in technical capabilities between developed and developing countries, with the latter contributing less than 3% of the worlds global prefab needs, and half of which are found in India (Ruddick, 2014; Smith & Narayanamurthy, 2008).

Although prefabrication has been hailed by technology and energy enthusiasts as a game-changer in the building industry (Savvides, Michael, Vassiliades, Parpa, Triantafyllidou & Englezou, 2023; Chippagiri, Bras, Sharma, & Ralegaonkar, 2022; Wu, Luo, Li, Wang, Bi & Antwi-Afari, 2021), the gradual acceptance of the phenomenon has caused the

transformational change expected of the prefab revolution appear to be more evolutionary than disruptive (Smith & Rupnik, 2019). Yet another shortfall in embracing prefab housing stems from the perception that potential owners are discouraged by the possibility of mass-produced factory building units ending up as nothing more than standardised duplicates of banal, stereotypical dwellings lacking in character and individualistic appeal. Traditional models of prefab housing are often thought to be uninspired or stereotypical, especially where mass-production of the building components are somewhat generic and potentially alien to the very users they are intended for (Gattupalli, 2024). As a show of confidence in the phenomenon, some writers have argued that prefab building may eventually have to learn to coexist peacefully with on-site buildings for the foreseeable future.

Figure 1: Alternative building materials. **Sources (Clockwise from top left):** Dua, (2024); Arkin, (2020); Thorsby, (2023); Jain, (2017)

Figure 2: Growing slums in Lagos, Nigeria **Sources (top and bottom):** Tade, (2021); Ogundeji, (2024)

Nonetheless, researchers and designers have been continuously encouraged to innovate sustainable low-cost housing solutions for developing countries for decades, which includes the introduction of prefab housing (Bras, Ravijanya, Torres de Sande, Riley & Ralegaonkar, 2020). Following the tumultuous economic downturn due to foreign exchange instability in the country, recent demands from the Nigerian public domain extend the call for a step further in innovation to include locally-sourced materials, a shift from the dependence on concrete- and steel-based construction, and improved access to mortgage schemes that are effective. Building construction costs have risen by as much as 300% since the beginning of 2024 and the resultant continued decline in the erection of adequate low-cost housing will invariably lead to the resurgence of more low-income squatter settlements in urban and semi-urban areas known as slums shown in Figure 2 (Oyekola, 2024; Ogundeji, 2024; Tade, 2021).

Some writers have attributed the slower-than-forecast uptick in prefab housing to the deep-rooted attachment of stakeholders and experts to age-old on-site production processes. With studies highlighting the persistence of the "culture of in-situ building" – driven by the use of hard hats, heavy site equipment, and drawn-out construction timelines (Smith & Narayanamurthy, 2008) – building culture affects the way buildings are not only erected, but

also how they are used. Previous studies of prefab housing in Nigeria fully acknowledge the non-availability of the technical know-how and the financial backing to advance the proliferation of manufactured homes (Kolo, Pour Rahimian & Goulding, 2014; Akeremale, 2020). In a drive to embrace emerging technology, conformity to normative values and behaviour within prefab spaces often gets overlooked: much to the detriment of designers, fabricators and eventual users. People will simply not desire spaces in which they can neither function nor carry on their normal lifestyle activities (Ajufoh, Prucnal-Ogunsote, Enwerekowe & Ndandok, 2023; Ehteshami, 2018; Torabi & Brahman, 2013). This has spurned some prefab manufacturers to consider the use of indigenous and contextual forms in modern adaptation (Figures 3 and 4) which may hold greater appeal to the diverse cultural value preferences of their intended users (Valsson, 2020; El-Abdi, Ofori, Zakaria & Aziz, 2019).

Figure 3: Hex House (prototype)
Source: McKnight (2016)

Figure 4: Traditionally inspired prefab prototypes.
Sources: Google images, Pinterest (n.d.)

This study takes a closer look at the cultural value preferences of prefab which could attract or dissuade Nigerian users, particularly the socially vulnerable rural or semi-urban dwellers, women and internally displaced people. The influence of key features of layout, use of materials and building form on the evolution of truly affordable prefab options will be reviewed with the aim of understanding the preferred options for manufactured homes in developing countries.

Methodology

This study utilised a systematic literature review and desk research of over 40 scholarly articles, published product reviews, media editorials, ethnographic case studies and a conceptual simulation to examine the potential influence of cultural value preferences affecting prefab housing adoption in Nigeria. The study plan includes a review of emerging prefab trends incorporating indigenous and vernacular architecture, highlighting the successes and shortcomings of existing models. The study examines low-cost building trends and styles which persist in semi-urban and rural communities across Nigeria, and discusses

how prefab (in conjunction with other modular construction) may be considered as a sustainable option to address housing shortages. The study analysis relies on a qualitative interpretation on identification, comparison and contrasts of underlying patterns and themes in off-site construction (Dudovskiy, 2018). The findings critically assess the national response to prefab building in Nigeria and the perceived level of acceptance of models which incorporate vernacular architectural layouts and styles. The data is presented as an architectural content analysis captured in the descriptive interpretative images of direct and published observations from where conclusions and recommendations can be drawn (Crossman, 2017). The risk of cultural bias in the analysis was minimised through the use of universal criteria that accepts contextual cultural differences of existing prefab models.

Findings and Discussion

This section of the paper presents the findings from the case study analysis of the perceived cultural impact on perceptions and acceptance of prefab building in Nigeria. It was Rapoport that posited that socio-cultural influences have a higher level of critical precedence over physical forces which determine how houses are built. It therefore stands to reason that socio-cultural influences (including religion), availability of materials, and environmental conditions are largely responsible for the ways in which different cultural groups accept and adopt housing styles, layouts, and models.

Cultural factors affecting the degree of acceptance of prefab: Styles, layouts and models

Despite several differences in the layout, styles and models of Nigerian vernacular architecture due to tribal peculiarities, research has shown many commonalities in the key features that define Nigerian traditional housing composition. Three key features include:

1. Courtyards (or the impluvium) – these held immense significance to the traditional housing set up from a perspective of clustering and a history of communality predicated on defence or social interaction. They functioned as shared spaces for interaction among family members, and were often used for performing various domestic functions which include cooking, religious rites and worship, folklore and entertainment. Courtyards also served as a transition space between public and private areas, as well as sources of natural light and ventilation.
2. Rectangular and circular based plans – several researchers maintain that "inferior" or "primitive" circular African buildings evolved into rectangular-based plans only after the influence of western cultures. Though the origins may be subjective, evidence shows most traditional Nigerian housing layouts evolved to combine rectangular-based plans for living spaces and circular-based plans for storage, utility and granaries.
3. Multi-room dwellings – Nigerian traditional architecture widely incorporated the use of multi-room configurations with a distinct separation of functions for living, sleeping, and services. This feature persists even in modern adaptations of Nigerian architecture which favour multi-room layouts in monochronic or polychronic capacities (Lodson, Ogbeba & Elinwa, 2018).

In Northern Nigeria, the impact of Islam which displaced many of the indigenous northern tribes and cultures from as far back as the 12th century introduced the isolation and privacy of

women to the "*cikingida*" (inner rooms) from where pubescent and non-family males were strictly prohibited access. Also, in Southern Nigeria, houses of tribes such as the Ibo and the Yoruba were comprised of individual windowless rooms around a colonnaded courtyard separated into private and public areas similar to northern dwellings, with male sections were separated from women and children (Figure 5). Consequent upon the climatic region, walls were traditionally made of mud bricks (wattle and daub, adobe or "*tubali*" – a pear-shaped earth brick with vegetable admixtures) or rammed earth, palm fronds, rough-cut wood or unhewn stones; roofs incorporated the use of sisal grasses, rammed earth domes or flat roof moulds, or bamboo (Umar, Yusuf, Ahmed & Usman, 2009; Minke, 2006).

Figure 5: Traditional Ibo homestead layout; traditional Hausa homestead layout, Hausa home façade and decorative motifs; traditional Yoruba elevation.
Sources (Clockwise from top left): Henderson & Henderson, (2024); Sa'ad, (1981); Bayt Al Fann, (n.d.), Alaayemoré, (n.d.)

The global impact of vernacular architecture on prefabricated buildings
There has been considerable effort in the development of prefab, modular and 3D printed model housing to reflect the aspirations and yearnings of vernacular architectural needs which are not only climate responsive, but also cost effective. However, a key finding from this

study is that insufficient research and development has gone into widely-acceptable adaptations of the aforementioned off-site construction models towards embodying sociocultural norms and practices. An example is the 2016 collaboration on the Hex House designed for refugees by Architects for Society (AFS). With a projected lifespan of 15-20 years and an estimated unit cost of $15,000-$20,000 (~₦18,000,000-₦24,000,000) for 40m^2 of floor space, the model hosts a central open-plan living space and walk-in kitchen, a bathroom and 2 bedrooms (Figure 6a and b).

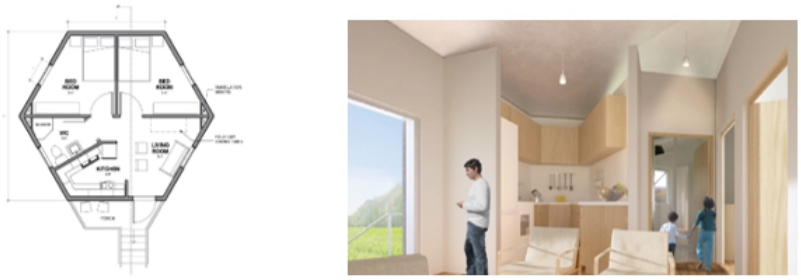

Figure 6a and b: Hex House floor plan and living room/kitchen interior.
Source: McKnight, (2016)

An online survey of property markets in Nigeria in the first quarter of 2024 revealed the average cost of an in-situ 2-bedroom unit of the same floor area would retail for ₦65,000,000; ₦3,290,000-₦7,410,000 being the cheapest available options (Nigerian Property Centre, 2024). These figures seem to suggest the Hex House would not only be an inadequate low-cost housing option for the socially vulnerable in Nigeria, the open-plan living and kitchen space deviates significantly from the culturally acceptable multi-room layout typically endeared to low-income home owners which imbibes a distinct separation of internal function.

Figure 7: BioHome3D prototype.
Source: The University of Maine (2022)

Another model examined in the study is the 3D printed BioHome3D© developed by the Advanced Structures and Composite Centre (ASCC) of the University of Maine, US in 2022 (Figure 7). This 56m^2 one-bedroom, one-bathroom prototypical eco-friendly model was developed without the use of any concrete-based material. Rather, the sustainable printing material used is a bio-based wood waste composite of pulverised sawdust and a polymer binder which becomes a pellet fed into the 3D printer. The layout is considered less open-plan than most prefab models which may lead to the development of multi-room models favoured by Nigerian vernacular trends, and it boasts a significantly lower carbon-footprint in both construction and operation, as well as customisable R-values. The building was also able to withstand severe weather extremities, making it one of the most environmentally-conscious prefab composites till date in a country like Nigeria with a diverse stream of climatic extremities. The production process of the BioHome3D almost totally eliminated any form of construction waste and the buildings are totally recyclable due to the nature of the materials used: meaning they have an almost unlimited lifespan. However, at an estimated cost of $40,000 (~₦48,000,000), the BioHome3D is among the higher end versions of prefab homes, but its advanced production process does present an option for the conversion of more readily available organic and inorganic waste in Nigeria such as single-use plastics, fly-ash, corn husks, etc. to potentially drive printing costs further downwards.

In a few countries such as Chile, Colombia and Indonesia, efforts have been made to infuse vernacular architectural styles and practices into the development of prefab homes designed to address the needs of low-income earners (Figures 8a, b and c). The use of locally sourced materials in conjunction with traditional building methods have led to the emergence of scaled affordable prototype homes which are respectful of the ancestral culture yet reflective of modern building techniques. Each of the submissions imbibe the principles of customisation and globalisation in order to address the specific local needs brought about by climate change and natural disasters.

Figures 8a, b and c: fusion of vernacular and modern low-cost prefab prototypes in Chile, Colombia and Indonesia.
Source: Ghisleni (2024).

These developments have also increased the dialogue on longevity and durability of prefab models made entirely of locally sourced materials such as wood, bamboo and earth, of which extensive product testing is highly recommended. This is of particular significance to the 18m^2 two-storey Pemulung House in Indonesia (Figure 8c) which was intended for transitory

migrant workers and not permanent residents. The use of locally sourced materials, however, resulted in a significant decrease in the unit cost of the vernacular-inspired modular units in South America and Asia bringing cost of prefabrication down to between $51 to $120 per square metre, excluding delivery or installation costs. The development of more resilient and durable models would invariably lead to a marginal increase in unit cost but is less likely to defeat the overall goal of achieving affordable housing for the urban and semi-urban poor.

Perception and reception of prefab in the Nigerian low-cost housing model

Entrance of prefab into the Nigerian construction industry has been widely viewed with both curiosity and scepticism. Product reviews, existing literature and field observations reveal prefab buildings are predominantly used as security outposts, construction site offices, storage facilities, institutional buildings (such as school building extensions and pop-up industries), and workshops. Use of prefab as a housing solution remains largely experimental and customised to suit the needs and aspirations of an elitist demographic and not the desirable urban or semi-rural poor dwellers (Figure 9). The Federal Republic of Nigeria [FRN] revised the National Building Code [NBC] (2006) to incorporate rules, minimum standards and guidelines for the erection of prefab buildings and the Federal Government offers several tax incentives for developers of modular construction projects to address Nigeria's housing shortage needs. Manufacturers such as Karmod®, EazyHomes Company®, Vitapur Insulation® and Nigerian Portable Cabins® offer a variety of single- and multi-floor bespoke housing configurations with starting prices from ₦5,000.000 for a single room dwelling, exclusive of transportation or actual installation costs. The steel framed structures are typically clad with shipping-container steel panels or Structural Insulated Panels (SIP's). However, most of the existing prefab prototypes advertised adopt distinctly western layouts and aesthetics, paying scant attention to traditional homage of vernacular architecture.

Figure 9: Exterior and interior images of 1-bedroom prototype prefab house, Abuja, Nigeria.
Source: https://tiktok.com/@sannivictor (2024)

Figure 10: Nigerian traditional construction practices using earth and other low-cost materials.
Source: Authors' field work (2023)

Traditional methods of in-situ construction which typically includes the use of rammed or compacted earth blocks, tin or aluminium roofing sheets and/or rough-hewn wood trusses (Figure 10) alongside selective use of modern elements such as concrete, glass and steel, have long been the preferred options for low-income dwellers and transitionary residences despite the economic strain they impose. The materials and construction techniques often provide for hamlet-style layouts composed of individual dwelling units delineated into public, semi-private and private zones to accommodate family activities. The observed available and evolving options in prefab housing make it possible to fuse the properties of speed and efficiency of modern construction with the feeling of belonging and identity from vernacular architecture. Radical developments in 3D printing techniques, such as in the BioHome3D, allows for customisation of design elements by also minimising the resultant effect of stereotypical duplications of housing units. Using alternative building materials made up of recycled waste or eco-friendly composites as sampled in the South American and Asian prefab and modular building production trends indicates the possibilities of eventually lower building costs to meet the needs of the vulnerable in society.

Figure 11 (Clockwise from bottom left): Traditional internal homestead zoning; isometric view, floor plan and exterior view of Nigerian vernacular prefab prototype.
Sources: Noma et al (2022); Authors' conceptual design (2024)

From a critical review of emerging trends in the fusion of high-tech composite building practices and sustainable vernacular architectural patterns, proposals can be made with the ultimate goal of providing truly affordable social architectural solutions with an affinity to endearing cultural values. An example of such a proposal is a prototype in Figure 11 above which conforms to vernacular housing patterns of northern Nigerian architecture having distinct internal zoning requirements with access to a screened-off external courtyard; finished with 3D printed SIP claddings reminiscent of the traditional materials of construction, namely earth (mud), wood and stone. The front room, which serves as a public reception space, is demarcated from the private sleeping space by the concealed kitchen which is traditionally considered as a semi-private area in the Nigerian homestead. The building façade utilises a mono-pitched roof and clean lines symbolic of northern Nigerian architecture, with relief motifs adorning textured walls, architraves and window casings.

Conclusion

This paper set to address the following research objectives: to identify the national response to the introduction of prefabricated housing solutions and examine the influence cultural factors exert in determining the degree of acceptance of prefabricated housing in Nigeria. The study also envisaged how prefabricated homes could incorporate the cultural ethos of vernacular architecture that will endear them to address the housing needs of the socially vulnerable in Nigerian society. Overturning the global housing deficit remains a leading sustainable development goal which can only be achieved when solutions proffered offer users climate responsive alternatives which align with their financial capacity and cultural building patterns. From a review of leading models and innovative trends in the prefabricated housing markets, the study finds that the foundations have been laid for sustainable, revolutionary collaborations between past building practices and future building techniques. The study recommends the continued targeting of efforts towards providing prefabricated housing for the urban and semi-urban poor, and other socially vulnerable users for whom the provision (or lack) of quality housing is a strong determinant for the existential growth of slums and other substandard informal settlements. The prospects for widespread integration of culturally-responsive prefab models in the Nigerian building space could become a key factor in the discussions on national housing policies and practicable mortgage schemes for the urban poor. The study recommends expanded empirical studies into users' preferences in prefab housing, particularly in developing countries where they are yet to be widely introduced to the general population. The study also suggests the extended collection of data from practical testing on prefab building modules such as 3D printing which have the capabilities of repurposing eco-waste and other sustainable building materials to lower the cost of purchasing prefab housing. Lastly, the study advocates for further collaborations between culture and innovation in architecture to ensure lasting values such as spatial arrangements, architectural identity, building shape and form, and so on, remain visible in evolutionary building trends.

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