Turning The Tide: Achieving Sustainability Through Building Information Modelling Utilisation For Housing Refurbishment

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Abstract

Concerned about the worsening climate change situation, poor adaption strategies in developing economies, and the increasing housing shortages for urban dwellers in Nigeria, this paper examines the role of building information modelling utilisation for housing refurbishment in increasing affordable housing supply and fostering the attainment of sustainability. The data for the study was elicited through a qualitative survey involving interviews of real estate developers who are members of the Lagos State branch of the Real Estate Developers' Association of Nigeria (REDAN) participating in housing development. Ten developers were contacted for the survey, with six volunteering to participate in the data collection process. The collected data were manually transcribed and interpreted using thematic content analysis. The findings revealed that BIM can improve the sustainable design of housing refurbishment. More so, all the respondents agreed that using BIM for housing renovation could eliminate material wastages associated with error-prone designs, thereby reducing cost and making housing affordable. Further findings showed that BIM usage for housing refurbishment could model activities throughout the building life cycle and reduce operational costs associated with building maintenance. The high cost of purchasing BIM software, inadequate knowledge, and lack of government support for BIM usage were identified as the key challenges inhibiting BIM usage for housing renovation by real estate developers. These findings have implications for combating the housing deficit and enhancing the provision of affordable and sustainable housing in the study area, scalable to the whole country.

Keywords: BIM, Housing, Housing Affordability, Refurbishment, Nigeria, Real Estate Developers

1. Introduction

Globally, there has been a growing concern about the impact of human activities on the environment. The built environment, which involves construction and housing development, contributes significantly to natural resource depletion, polluted atmosphere, and degraded ecosystems (Hammond, Nawari & Walters, 2014). As affirmed by the United States Energy Information Administration, buildings are among the highest energy consumers, as 47.6% of total energy generated in the United States is consumed by buildings and accounts for 74.9% of electricity use. In the United Kingdom, about 45% of the entire CO2 emission emanates from buildings, with residential dwellings accounting for 27% of carbon emissions (Park & Kim, 2014). As a result, the housing sector has been identified as the most significant contributor to climate change as it has been found to emit 44.6% of estimated greenhouse gas emissions (McGraw-Hill, 2014). As such, the housing sector is key to attaining sustainability by reducing carbon emissions and minimising the generation of greenhouse gases inducing climate change. In combating the worsening climate change situation in most countries of the world, governments, international aid agencies and civil societies have become particularly concerned about the inadequacies and inability of adaptation strategies. While developed countries have made appreciable progress in reducing their carbon footprint by adopting a wide range of adaptation strategies, such as housing refurbishment, most developing third-world countries continue to grapple with combating the climate change menace. Several studies such as Park and Kim (2014), Zulkefli, Mohd-Rahim and Zainon (2020), Senior (2020), and Liao, Ren and Li (2023), among others, have documented that building information modelling (BIM) enabled housing refurbishment leading to the renovation of existing buildings is an effective way of reducing energy consumption and carbon emission. Zulkelfi *et al*. (2020) contended that housing refurbishment upgrades existing buildings through green technologies and eco-friendly materials, thereby enhancing environmental sustainability.

The slow uptake of innovative technologies, including BIM, in developing third-world countries implies that traditional practices and processes have continually hampered the quest for sustainability and the attainment of sustainable development goals. These practices manifest in how goods are manufactured, bridges and roads constructed and houses built. For example, studies beginning with the pioneering work of Eastman, Teicholz, Sacks and Liston (2011) have reported the ability of BIM to effect vital changes to the traditional ways of producing housing. The study contended that the application and adoption of innovative technology of BIM for construction could fundamentally alter traditional practices, ultimately fostering a sustainable drive. As such, using BIM technology in housing refurbishment could assist in resolving the issues of communication and information sharing, which is problematic among the construction team and leads to the integration of efforts, improved coordination, and minimised errors and waste, which fundamentally optimises resource requirements, resulting in reduced housing development costs. More so, Park and Kim (2014) noted the role of BIM in improving sustainable housing development by enhancing the fragmented and complex nature of housing production, integrating stakeholders' requirements and technical resources, as well as lowering high development costs, thereby facilitating the attainment of sustainability. BIM, therefore, provides an innovative means of achieving affordable housing delivery.

Despite the increasing potential of BIM in enabling housing refurbishment, its adoption remains very low. Homeowners and real estate developers have not embraced this innovation in improving housing stock. More so, available evidence on BIM usage for housing refurbishment and renovation centred on developed countries, notably the United Kingdom and the United States of America. This suggests that the phenomenon is yet to gain traction in developing countries, including Nigeria. The country grapples with acute housing shortages arising from the inability of supply to meet existing demand. Besides, the resource constraints and national budget limitations experienced by Nigeria have constricted the availability of funds for the production of new houses. Hence, the provision of publicly-funded large-scale housing is limited, while the existing old housing stock provides the basis for meeting the accommodation needs of the citizens. The national housing policy recognises private sector participation as a strategy for ensuring housing development in Nigeria. As

such, most of the new housing developments have been by individual homeowners or through private developers.

As a gateway to civilisation in Nigeria, Lagos has a lot of old housing stock, which is unsuitable for habitation. The renovation of these houses could close the housing gap and foster sustainability. However, there is limited information on the role of BIM in housing renovation as most studies on BIM in Nigeria have focused mainly on its adoption, readiness, risk factors and implementation barriers in the architecture, engineering and construction (AEC) industry. The study, therefore, aims to assess the role of BIM in housing refurbishment in Lagos, Nigeria, with a view to providing information for improving ageing housing and enhancing sustainability. The rest of the paper is structured as follows: following this introduction is the literature review. The third section focuses on the methodology, while the results and discussions are in the fourth part. The paper concludes in the fifth section.

2. Literature Review

Incremental housing development (IHD), as a concept, has been discussed and analysed by various authors in the literature. Studies such as those conducted by Baqutayan et al. (2015), Park et al. (2018), and Roberto (2003) have argued that incremental housing development (IHD) focuses on design strategies that allow for a progressive expansion and improvements of housing units. Such houses are inhabitable even when construction is incomplete, thus addressing the immediate housing needs of the occupants. This approach helps reduce the initial cost of housing development as low- and middle-income earners struggle to meet necessities such as food, clothing and education. Authors such as Ronald and Chiu (2010) and Wibowo and Larasati (2018) have established that IHD considers the dynamics involved in land acquisition, finance, infrastructure, building materials, and labour. This implies a step-by-step approach towards housing construction. Such construction spans a reasonable period in terms of quality and size (Hasgül, 2016). However, this reflects the function of several factors, such as those embedded in individual household income and expenditure metrics.

2.1. BIM Implementation for Housing Renovation

BIM has been a subject of interest in the literature, with varying definitions and descriptions from writers, authors, researchers, and government agencies. These diverse definitions notwithstanding, scholars and researchers agree that BIM facilitates collaboration and information exchange among construction professionals for successful project delivery. It also integrates efforts while incorporating stakeholder needs into projects, minimising delays and wastage and enhancing productivity. In this way, BIM can be described as multi-dimensional computer modelling applied to design structures and stimulating the construction and operational phases of building projects (Khoshfetrat, Sarvari, Chan & Rakhshanifar, 2022). With dimensions varying from 3D to 7D, BIM is useful for stakeholders from the beginning of a project to its operation and maintenance phase for increasing efficiency.

Although the uptake of BIM for housing refurbishment is low, the potential of BIM in greening existing buildings, reducing energy consumption and reducing carbon footprints of old housing stock, which ultimately galvanises the attainment of environmental sustainability, has been noted by studies (see for example Park & Kim, 2014; Hammond et al., 2014; Kim & Park, 2018; Senior 2020; Liao et al., 2023). For instance, Kim and Park (2013) investigated the possibility of utilising BIM as an information management system for housing refurbishment in the United Kingdom. The finding affirmed BIM's potential in facilitating housing refurbishment based on the availability of sufficient information sets. The study only documented the possibility of BIM usage for housing refurbishment and was limited to construction professionals. To overcome this shortcoming, Park and Kim (2014) examined homeowners' preferences and decision-making factors in developing essential input data for housing refurbishment in the United Kingdom. Based on a survey of 112 and 39 homeowners and construction professionals involved in housing renovation, the capability of BIM usage in facilitating housing refurbishment by incorporating clients' preferences and material choices early in the design stage was affirmed, a crucial indicator of enabling sustainable housing development. The study focused mainly on individual homeowners rather than corporate organisations involved in large scale development. Furthermore, Hammond et al. (2014) investigated the feasibility of BIM in facilitating the sustainability of existing buildings through renovation and retrofitting activities in

the United States. The outcome showed the potential of BIM integration for housing renovation to facilitate sustainable design and renovation practices that could promote the greening of old buildings.

In another study conducted in the United Kingdom, Alwan (2016) examined the role of BIM in housing refurbishment by developing a proposal for a BIM performance framework for the maintenance and refurbishment of housing stock. Based on the simulation of BIM, the study established the possibility of BIM adaptation for effective housing maintenance towards the attainment of sustainability. This agrees with the research of Kim and Park (2016), which recognised the capability of BIM to facilitate sustainable housing refurbishment in the United Kingdom. Again, Kim and Park (2018) examined the feasibility of BIM as an information management platform to ascertain the financial and environmental profitability of housing refurbishment based on life cycle cost analysis. Employing data based on a BIM simulated case study, the findings highlighted the suitability of BIM as an information management platform to enhance the life cycle cost analysis of existing housing and enhance sustainable housing renovation decisions. The potential was, however, limited by the interoperability difficulties crippling seamless information among BIM tools and materials. Likewise, Okakpu et al. (2018) identified the potential of leveraging BIM for housing refurbishment in the United Kingdom subject to the incorporation of essential factors such as refurbishment attributes, environmental influence, stakeholders' interaction and structure optimisation which influences the maximisation of BIM tools for successful housing refurbishment. These studies only documented the possible utilisation of BIM to enhance housing renovation. The specific contributions of BIM in improving the refurbishment of existing housing, thereby enhancing housing affordability, were not identified.

More so, Senior investigated the role of BIM in fostering the sustainable renovation of residential buildings in Norway (Senior, 2020). Using qualitative and quantitative data obtained from homeowners, the study recognised the role of BIM in enabling citizens' engagement for successful housing refurbishment, which could entrench housing sustainability. This assertion was strengthened by the work of Zulkefli *et al*. (2020), which affirmed the ability of BIM to ensure the integration and management of activities throughout the phases of the life-cycle of buildings, including greening existing

buildings through refurbishment to attain sustainability. Sertyesilisik, Sertyesilisik, Cetin, and Ocakoglu (2021) investigated the potential of BIM dimensions and their application for enhancing the sustainability of affordable housing. The study established the usability of BIM for energy and facility management, and it found the potential of the integrated application of BIM to add value to housing through reduced energy usage and greening activities throughout the entire life cycle. More so, Liao *et al*. (2023) recognised the increasing potential of BIM among all the building renovation technologies to seamlessly facilitate sustainable housing renovation by incorporating users' preferences and information sharing at the early stage of the decision-making process, which could optimise resource requirements and material usage. While fulfilling their aims and objectives, these studies focused on professionals' opinions on housing construction. The opinions of real estate developers engaging the professionals in housing development projects were not investigated. Since BIM usage is often implemented at the firm level, real estate developers' opinions are critical to entrenching BIM deployment for housing refurbishment.

The corollary of the preceding review indicates that despite the growing recognition of the significance of BIM in enhancing the sustainability of existing buildings as documented by the reviewed studies, its usage is still limited to the United Kingdom, Australia, France and the United States of America. Its uptake has yet to gain traction in many countries due to the inadequacy of existing studies documenting the practice. As such, there is low research evidence on the suitability of BIM for housing refurbishment as an innovative means of achieving housing affordability and realising the sustainability agenda. This is even more critical in developing countries, particularly in sub-Saharan Africa, including Nigeria, where housing affordability is problematic, and issues of carbon emission, energy shortages, and housing deficits are endemic and alarming.

2.2. BIM Adoption in Nigeria

Nigeria is a BIM infant country as the state of BIM deployment has been generally slow, relative to what obtains in other emerging economies. However, despite the slow uptake of BIM, there is evidence of BIM usage in the AEC industry. For instance, studies such as Olapade and Ekemode (2018), Ibrahim (2019), Olawumi and Chan

(2020), and Ekemode (2024) have documented the evidence of BIM usage in the construction, infrastructure development and facility management sectors. BIM adoption revolves around the intermediate level, with the current usage level restricted to 3D and 4D levels. This shows that the country is still at Level 1 on the BIM maturity matrix. Studies such as Olawumi and Chan (2020) and Ekemode (2024) have attributed this unpalatable situation to a plethora of BIM application obstacles endemic in Nigeria. Factors such as lack of government support to facilitate adoption, financial incapacitation constricting software acquisition and deployment, absence of government policy framework mandating BIM usage, poor technical know-how and expertise, high cost of deployment and lack of client demand were identified as inhibiting effective BIM utilisation in Nigeria (Olawumi & Chan, 2020; Ekemode, 2024). Besides, there is a lack of empirical evidence on BIM's usage for refurbishing existing housing stock in Nigeria despite recognising its innovative role in enhancing affordable housing production. This study fills this knowledge gap by examining the role of BIM technology in housing refurbishment in Lagos, Nigeria.

3. Methodology:

A qualitative research approach is adopted for the study. As such, data utilised for this study were sourced from interviews held with private real estate developers involved in residential property development in Nigeria. The collapse of public housing provision in the country necessitates the choice of private developers. More so, a large proportion of the existing housing stock in Nigeria is held by private individuals and corporations. Besides, the national housing policy recognises private sector participation as a strategy for ensuring housing development in Nigeria. As such, most of the new housing developments have been by individual homeowners or through private developers. The choice of Lagos is justified as its status as the economic centre-point and the gateway to civilisation in the country. As a former British Colony, Lagos has sizeable holdings of old housing stock with the potential to increase the Nigerian housing situation if refurbished. In this wise, ten property developers who are members of the Lagos State branch of the real estate developers' association of Nigeria (REDAN) were initially contacted to participate in the research. After several persuasions, only six developers agreed to be interviewed, and this accordingly forms the basis for the study. The low number of respondents reflects the difficulty of

obtaining qualitative and evidence-based data in a country like Nigeria, where research apathy is very rife. Moreover, since real estate developers in Lagos are homogenous, there is a likelihood of some level of convergence in their perception. This suggests that reliance on the opinions of the six respondents could offer insights into the perception of other real estate developers concerning the investigated phenomenon.

Data was collected using a semi-structured interview guide using open-ended questions. The interviews were manually transcribed using thematic content analysis, which arranged them into themes for meaningful interpretation. The profiles and codes of the respondents are summarised in Table 1.

Table 1: Profiles and Codes of the Respondents

Code	Sex	Position	Years of Experience	Educational Qualification	Professional Qualification	Type of Housing Developed
RED 1	M	Managing director/CEO	15 years	B.Sc.	SURCON, MNIS	Terrace, block of flats
RED 2	F	Project Manager	12 years	B.Sc., MArch	Registered Architect	Detached houses, Terrace
RED 3	M	Manager	10 years	B.Sc.	ACA	Luxury apartments
RED 4	M	Builder	9 years	HND, PGD, M.Sc	MNIOB, Registered Builder	Block of flats, Terrace
RED 5	M	Project Manager	18 years	B. Sc., MBA	MNIOB, Registered Builder	Detached houses, Flats
RED 6	M	Structural Engineer	12 years	B. Eng.	MNSE, Registered Engineer	Terrace, Maisonette

The respondents' profiles in Table 1 showed that they have been involved in housing development for more than nine years. More so, they possess requisite academic and professional qualifications germane to housing development, as a vast majority

belonged to the built environment professions of architects, builders, and engineers. As such, their opinions could be highly accurate and reliable.

4. Results and Discussions

The analysis of the data collected from the respondents revealed four themes about the state and role of BIM utilisation for housing refurbishment in the study area. Based on these themes, this section discusses these findings.

4.1. Enhancing Sustainable Design

One of the benefits of BIM, as identified by researchers, is its ability to improve the design of building and construction projects. The study also found this to be one of the key attributes of BIM in the housing sector. As revealed by the findings, BIM is essential in facilitating the sustainable design of housing refurbishment projects. One of the interviewees affirmed that "…. through the usage of BIM, energy requirements and consumption pattern of the building under renovation is predicted by the 3D models… (RED 4)". This finding revealed that infusing 3D BIM models with energy usage information could guide property developers on the sustainability of the buildings regarding energy efficiency. As such, BIM has the potential to ensure the incorporation of green features into existing housing to attain sustainability. This agrees with the findings of Hammond et al. (2014) and Sertyesilisik et al. (2021), which recognise the role of BIM in greening existing buildings and reducing carbon footprints. Furthermore, using BIM could also ensure the selection of appropriate designs among a range of possible alternatives based on the prediction of costs associated with the operational phase of the renovated housing throughout the whole life cycle. In this regard, respondent RED 2 averred that "…BIM enabled design for renovation has the potential of guiding developers on the cost and other resources associated with the development option, and this transcends construction cost but includes operational cost…(RED 2)". The selection of appropriate design among a range of alternatives enabled by BIM usage could infuse sustainability into housing renovation. Through this, real estate developers are able to evaluate the resource requirements of alternative designs throughout the entire life cycle. This would guide rational and well-informed decisions in selecting the design that optimises resource use and conserves depleting natural resources. This agrees with the submission of studies such as Kim

and Park (2016), Kim and Park (2018), and Zulkefli et al. (2020), affirming the ability of BIM to make sustainability decisions at the design phase - the earliest stage of any housing refurbishment activity.

4.2. Material Usage and Quantification

The study also established BIM's critical role in using construction materials required for implementing housing renovation. Respondent (RED 5) noted that "… BIM optimises the use of building construction materials … (RED %)". This is one of the key potentials of BIM usage in housing refurbishment and is critical to attaining the sustainability agenda. For instance, the utilisation of BIM is helpful in the feasibility and viability phase of housing development as it enhances the optimisation of resource use, ultimately reducing development costs. Apart from ensuring sustainability, it also guarantees profitability, which is a key driver of developers' investment decisions in the housing market. In this regard, respondent (RED 1) retorted that "… lower housing renovation costs reduce project cost, thereby increasing developers margin … (RED 1). This translates to reduced rent and sale prices, implying that BIM usage can reduce development costs, profit margins of real estate developers and rent/sale prices of housing refurbishment projects.

Similarly, using BIM leads to strict adherence to design and project timelines. As such, it could help minimise design errors, which often result in material wastage. This strengthens the findings reported by Liao et al. (2023) on the capability of BIM to ensure resource optimisation when deployed for building renovation. The visualisation capability of BIM is also relevant in renovation. Respondent (RED 6) opined that "…one key advantage of BIM usage for housing renovation is the visualisation of the end product – what the building would look like upon completion of renovation…". By visualising the outcome of the proposed housing renovation project, BIM effectively improves project design implementation during the construction phase, reducing design errors requiring corrections, which results in the wastage of materials. This could assist in eliminating challenges associated with project delivery, such as cost and time overruns, project delays and client dissatisfaction. In addition, visualisation enables risk prediction and identification of hazards and incorporates strategies for their elimination (Khoshfetrat et al., 2022).

4.3. Collaboration and Information Exchange

A key attribute of BIM is its ability to facilitate interoperability and ensure collaboration and information exchange in the construction industry (Eastman et al., 2011). This is critical to resolving fragmentation, which is a problem among the development team. The study identified the attribute as one of the critical roles of BIM usage in refurbishing existing housing. The respondents were unanimous in recognising the ability of BIM to promote teamwork and understanding among the members of the development team and all professionals participating in the housing renovation project. This eliminates conflicts and promotes stakeholder engagement, reducing conflicts, frictions and disagreements among the development team that could impinge on the pace of work. This validates the assertion of Okakpu et al. (2018), affirming BIM's capability to seamlessly integrate project stakeholders' aspirations, leading to improved outcomes of housing refurbishment projects.

4.4. Functionality and Satisfaction

BIM can enhance the functionality and satisfaction of housing refurbishment projects. This is done by enhancing the decisions concerning the proper location and siting of facilities such as lifts, elevators, and other common services, including walkways, open spaces, parking lots, electricity mains, and sewer lines, without which most housing developments, vast estates, would be deemed functionally obsolete. The digital representation attribute of BIM could depict how these could be appropriately and adequately replicated in housing refurbishment projects to enhance building functionality and users' satisfaction.

However, all the respondents agreed that these enormous potential and utilisation benefits notwithstanding, BIM utilisation for housing refurbishment is still at its lowest ebb. All the respondents reported the usage of 3D BIM for some of their housing projects in the last two years. This shows that BIM usage in housing development is gaining traction relative to the results of earlier studies like Ekemode and Olapade (2021). More so, the little use of BIM in refurbishing houses by real estate developers was ascribed to contributory factors like the high cost of purchasing BIM software, inadequate knowledge and lack of government support towards BIM. This validates the findings of Ekemode (2024), which ascribes the slow usage of BIM in the housing

sector of emerging economies like Nigeria to inhibiting factors, notably cost of acquisition and deployment and operating environment constraints.

Based on these findings, BIM, when used for housing refurbishment, could lower the costs associated with housing development, particularly throughout the life-cycle phases. This ultimately reduces the rising overall cost of housing production, which is incredibly high in an inflationary economy like Nigeria. Thus, the innovative digital technology of BIM usage is an innovative means of galvanising sustainable affordable housing delivery. Therefore, effective and appropriate deployment of BIM in the renovation of existing housing stock in Nigeria could increase housing availability by reducing the acute housing deficit prevalent in the country, especially for the urban poor.

5. Conclusion and Further Research

This paper examines the role of BIM in housing refurbishment as a means of greening existing buildings and enhancing the realisation of the sustainability agenda. This is done from the lens of real estate developers involved in housing production in Lagos, Nigeria. The results showed that BIM is useful in enriching the sustainable design of housing refurbishment projects by facilitating the selection of appropriate designs among a range of possible alternatives based on the prediction of energy requirements and carbon reduction. Furthermore, BIM uptake could eliminate design errors, reduce materials' wastage, and optimise resource use. Also, the potential of BIM to promote cooperation among members of the development team involved in housing development, which is critical to project success, was established. The study also found that acquisition and deployment cost issues and the absence of government support hamper the realisation of these utilisation benefits.

These findings indicate that BIM technology helps facilitate sustainable housing refurbishment, which could promote sustainability by incorporating green features into existing buildings, thereby promoting energy efficiency, reducing carbon emissions on the one hand and increasing housing supply and affordability on the other hand. Emanating from these findings, the study concludes by recognising the role of BIM in enhancing the success of housing refurbishment. Apart from greening old housing

stock and promoting a sustainable built environment, it increases housing stock, which could assist in affordable housing delivery by lowering the country's housing deficit. To facilitate BIM usage, it is pertinent for developers involved in housing refurbishment to pay adequate attention to BIM inhibiting factors. For instance, to overcome the challenge associated with the high cost of deployment, organisations are encouraged to collaborate to aggregate the required finance to acquire BIM. The government should fulfil its responsibility as an enabler by taking centre stage in BIM acquisition and employment. It is also necessary for the Nigerian and Lagos State governments to formulate and initiate a policy incorporating BIM into the National Housing Policy to guide sustainable housing development and renovation similar to what is obtained in the United Kingdom. BIM could be mandated for residential property development and refurbishment, fostering BIM uptake in the sector.

The potential of BIM for housing refurbishment from the perspectives of property developers was examined in this study. Since the housing market is populated by several players, such as housing corporations and mortgage institutions, further studies could explore the opinions of these participants. More so, further studies could explore the development of an integrated framework/model for BIM usage in housing renovation. This study only focused on Lagos, one of the three first-tier cities in Nigeria. Further research could be undertaken to document this phenomenon in the other first-tier cities of the country.

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