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Research Article

Leveraging BIM for Climate Responsive Building Design in South-west Nigeria

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Abstract

Building Information Modelling (BIM) is increasingly recognised as a transformative tool in architectural design, particularly for enhancing sustainability and climate responsiveness. However, its adoption in Nigeria, especially in South-West Nigeria, remains underexplored. This study assesses the current level of BIM adoption among architecture and other construction professionals in the region, with a focus on its application in climate-responsive building design. A mixed-methods approach was employed, including a literature review, surveys, and expert interviews, to evaluate awareness, usage patterns, challenges, and potential benefits of BIM in sustainable architecture. Findings reveal that while BIM is gaining recognition, its integration into climate-adaptive design remains limited due to factors such as high implementation costs, lack of technical expertise, and inadequate policy support. The study highlights the need for targeted training programmes, policy interventions, and industry collaboration to enhance BIM adoption for sustainable architecture in South-West Nigeria. The findings contribute to the discourse on digital innovation in climate-responsive design and provide recommendations for increasing BIM utilization in the Nigerian built environment.

Keywords: Architectural Sustainability, BIM Adoption, Climate Responsive Design, Digital Innovation, South West Nigeria

1. Introduction

Building Information Modelling (BIM) has emerged as a transformative approach in architecture, engineering, and construction (AEC) industry, offering enhanced efficiency, collaboration, and sustainability in project delivery [1]. By facilitating comprehensive digital representations of building components, BIM enables stakeholders to visualise, simulate, and optimise various aspects of design and construction, thereby promoting sustainable practices [2]. In the context of Nigeria, particularly the South-West region, the integration of BIM into climate-responsive architectural design presents a significant opportunity to address environmental challenges and improve building performance [3]. Nigeria's diverse climatic conditions necessitate architectural solutions that are both adaptive and sustainable. Climate-responsive design focuses on creating buildings that harmonise with their environmental context, utilising passive strategies such as natural ventilation, day lighting, and strategic shading to enhance occupant comfort and reduce energy consumption [4]. The South-West region, characterised by a tropical climate with distinct wet and dry seasons, requires tailored design approaches to mitigate heat gain and manage humidity effectively. Integrating BIM into this process can significantly enhance the precision and effectiveness of such strategies [1].

Despite the global recognition of BIM's benefits, its adption in Nigeria has been gradual and faces several challenges [5]. Studies indicate that while there is an increasing awareness of BIM among Nigerian construction professionals, widespread implementation remains limited due to factors such as high initial costs, lack of technical expertise, and insufficient policy support [2]. Specifically, in the South-West region, research has shown that architectural firms are beginning to recognise the potential of BIM; however, comprehensive adoption is still in its nascent stages [3]. Many firms struggle with the lack of trained personnel, software affordability, and resistance to change, which further hinders BIM integration into sustainable design [4]. The integration of BIM into climate-responsive design not only facilitates the creation of sustainable buildings but also aligns with global efforts to combat climate change [1]. By leveraging BIM's capabilities, architects and engineers can simulate environmental performance, optimise resource efficiency, and ensure that buildings are resilient to climate variations [5]. This synergy is particularly pertinent for Nigeria, where sustainable development is crucial for economic growth and environmental preservation [2]. This study aims to assess the current adoption of BIM in climate-responsive architecture within South-West Nigeria. By evaluating the extent to which BIM is utilised in sustainable design practices, identifying the barriers to its implementation, and exploring strategies to enhance its adoption, the research seeks to provide insights that can inform policy, education, and practice. This is because fostering the integration of BIM into climate-responsive design can contribute to the development of buildings that are not only environmentally sustainable but also culturally and environmentally viable in the Nigerian context.

1.1. Building Information Modelling (BIM) and Climate-Responsive Architecture

Building Information Modelling (BIM) has emerged as a transformative digital methodology within the architecture, engineering, and construction (AEC) sectors. It facilitates the creation of comprehensive digital representations of physical and functional characteristics of built environments, enabling stakeholders to collaborate effectively throughout a project's lifecycle [1,6]. Recent advancements have integrated BIM with Artificial Intelligence (AI) to enhance energy efficiency in residential buildings. For instance, a study by Luo demonstrated that incorporating AI algorithms into the BIM framework allows for dynamic adaptation and estimation of energy usage based on real-time occupant behaviours and environmental conditions, leading to more accurate energy consumption projections [7]. Similarly, Wong, Ge and He noted that AI-enhanced BIM platforms can streamline energy diagnostics and automate sustainable design decisions [8]. The integration of BIM with emerging technologies such as Internet of Things (IoT) also fosters real-time monitoring and predictive maintenance, thus improving building performance [9].

Climate-responsive architecture focuses on designing buildings that harmonise with local climatic conditions to optimise energy efficiency and occupant comfort. This approach emphasises passive design strategies such as natural ventilation, day lighting, and thermal mass utilisation to reduce reliance on mechanical systems [10]. Integrating BIM into climate-responsive design processes offers significant advantages. According to Wang, Abdul-Samad, and Salleh BIM enhances sustainability through energy simulations, material selection, waste reduction, and energy monitoring across the entire lifecycle of green building projects [11]. Likewise, Ghaffarian argues that BIM-based analysis enables early-stage climate-adaptive design iterations, significantly improving building performance outcomes [12]. Similarly, Alwan and Jones emphasised the role of BIM in facilitating evidence-based decisions for thermal performance and carbon footprint optimisation during design [13].

Furthermore, BIM's capabilities extend to facilitating compliance with green building certification systems. Numan, Saadat, and Farooq highlighted that BIM tools, when integrated with platforms such as Revit-Insight 360, enable rapid multi-objective optimisation, leading to lower energy use intensity and reduced lifecycle costs [14]. This integration supports detailed thermal zoning analysis, capturing realistic solar gains and heat storage effects, thereby right-sizing heating equipment and improving overall building performance. Similarly, Azhar, Khalfan and Maqsood noted that BIM provides the data granularity required for LEED and BREEAM assessments, enhancing transparency and reducing certification timelines [15]. Additionally, Onyenokporo and Oke observed that digital models incorporating real-time environmental simulations help address compliance gaps during post-occupancy evaluations in tropical climates [16].

The synergy between BIM and climate-responsive architecture is further exemplified in urban planning contexts. Eshraghi, Talami, Dehnavi, Mirdamadi and Zomorodian employed Explainable AI techniques to assess the impact of urban morphology on energy and environmental performance in arid climates [17]. The findings of the study underscore the importance of building shape, window-to-wall ratio, and neighbouring building configurations in influencing energy efficiency, demonstrating the potential of BIM in developing climate-responsive urban designs. In a similar study, Rezaei, Shokry and Mohammadi applied BIM-integrated urban simulations to evaluate microclimate effects on pedestrian comfort and solar access, indicating the tool's relevance in compact city planning [18]. Moreover, the integration of BIM with Geographic Information System (GIS) enhances spatial analyses for urban-scale sustainability assessments [19]. The integration of BIM into climate-responsive architectural practices offers a robust framework for enhancing energy efficiency, sustainability, and occupant comfort. By leveraging BIM's advanced simulation and analysis capabilities, architects and engineers can design buildings that are better adapted to their environmental contexts, contributing to the broader goals of sustainable development.

1.2. BIM implementation and Climate Responsive Design in Nigeria

1.2.1. Enhancing Climate Responsive Design Through BIM

The integration of Building Information Modelling (BIM) into climate-responsive design presents vast potential for achieving energy-efficient and sustainable built environments. BIM facilitate precise simulation of site-specific environmental factors such as solar radiation, prevailing wind patterns, and thermal performance, enabling architects and engineers to optimise passive design strategies including natural ventilation, day lighting, and thermal mass usage [7,11,18,]. BIM-based tools like Revit and Insight30 support rapid iterative analysis and allow for early-stage testing of design options in alignment with local climatic contexts [12,14]. Moreover, BIM's integration with AI, IoT, and machine learning enables predictive environmental modelling and real-time adjustments to occupant behaviours, further enhancing energy conservation strategies [8,9]. The ability of BIM to facilitate performance-based design approaches significantly contributes to the implementation of sero-energy buildings and supports life-cycle sustainability analysis [13,15].

1.2.2. Current State of BIM Adoption in Nigeria

Despite the global momentum surrounding BIM integration in sustainable architecture, Nigeria's adoption of BIM remains slow and fragmented. A major challenge is the limited awareness of BIM's potential among stakeholders, including architects, engineers, and policy-makers [1,6]. Other factors such as inadequate technical expertise, high software acquisition costs, and lack of localised BIM standards have further hindered widespread implementation [16,20]. Studies have shown that many built environment professionals operate with conventional 2D CAD systems, leaving BIM underutilised in mainstream practice [21]. Institutional resistance to change, coupled with the absence of national mandates for BIM adoption, continues to pose barriers to innovation in design and construction workflows [22,23]. Furthermore, the educational curriculum in many Nigerian architecture schools has yet to fully integrate BIM-based training, thereby contributing to the skills gap in the industry [24].

1.2.3. Policy Environment and Government Initiatives

The Nigerian government has shown a growing interest in sustainability in sustainability and digital transformation within the built environment. Notably, the National Climate Change Policy and Renewable Energy Master Plan provide strategic frameworks for promoting low-carbon development and environmental stewardship [25,26]. However, these policies often lack implementation mechanisms for BIM integration in architectural practice. Although the National Building and Road Research Institute (NBRRI) and the Nigerian Institute of Architects (NIA) have acknowledged the relevance of BIM, a binding national roadmap remains absent [16,27]. Countries like the UK and Singapore have demonstrated the effectiveness of government-led BIM mandates, which could serve as a model for Nigeria [8,12]. Without targeted interventions, such as incentives for BIM-based green building projects, capacity building, and public procurement reforms, Nigeria risks lagging behind in sustainable construction innovations [15,13]. Moreover, the limited synergy between climate policies and digital design frameworks calls for an urgent revision of existing policy tools to embed BIM as a core mechanism for climate-resilient development [6,22].

1.2.4. Opportunities and the Way Forward

Despite existing barriers, opportunities abound for advancing BIM-driven climate-responsive architecture in Nigeria. Recent pilot projects in Lagos, Abuja, and Port Harcourt demonstrate that with proper leadership and investment, BIM can substantially improve project delivery timeliness and environmental performance [21,24]. The increasing digital literacy among younger professionals and the proliferation of mobile/cloud-based BIM solutions also present promising trends [1,20]. Collaborative partnerships between academia, industry, and government – especially through joint training programmes and research grants – could accelerate local capacity and stimulate demand for BIM-centric design approaches [6,23]. Moreover, aligning BIM application with Nigeria's Nationally Determined Contributions (NDCs) and Sustainable Development Goals (SDGs) could provide and integrated pathway for achieving climate resilience in the built environment [11,18]. To fully harness BIM's potential, stakeholders must champion a paradigm shift towards digital innovation as a strategic pillar for environmental sustainability in architectural design.

2. Materials and Methods

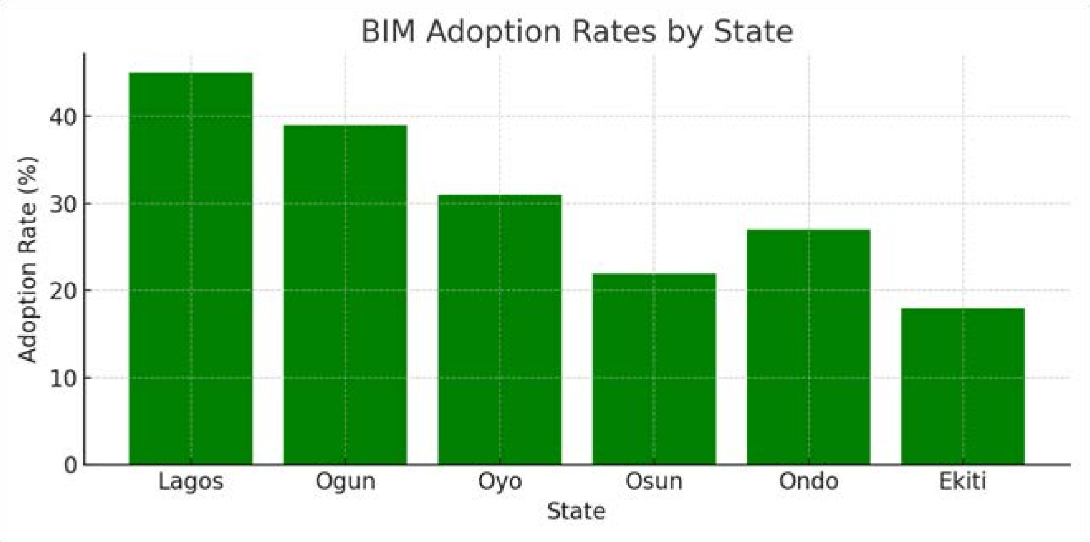
This study employed a quantitative research approach, using structured questionnaires to evaluate the current adoption and application of Building Information Modelling (BIM) in climate-responsive architecture across South-West Nigeria. The methodology was chosen for its ability to generate empirical data that support statistical analysis of professional awareness, using patterns, challenges, and recommendations related to BIM in sustainable design. A pilot study was conducted to validate the instrument before full-scale deployment. This research covered the six states in South-West Nigeria Lagos, Ogun, Oyo, Osun, Ondo, and Ekiti due to their high concentration of built environment professionals and relevance to climate-responsive design, given the region's humid tropical climate. The target population comprised registered architects, engineers (structural and MEP), builders, BIM consultants and construction managers. A stratified random sampling technique ensured representation across disciplines and locations. The sample size was determined using Yamane's formula (197), with adjustments for potential non-responses. Questionnaires were distributed both online and physically, leveraging platforms of NIA, COREN, NIOB, and LinkedIn groups to maximise reach. The instrument collected data on demographics, BIM awareness, adoption levels, climate responsive design applications, perceived barriers, and suggested improvements. Responses were analysed using SPSS, employing descriptive statistics, chi-square tests, and regression analysis to establish trends and relationships. Ethical standards were upheld through informed consent and anonymity of respondents.

3. Findings and Discussion

3.1. Findings

The analysis was based on responses from 278 validly completed questionnaires distributed across the six states in South-West Nigeria. The demographic breakdown shows that 41% of respondents were architects, 29% were engineers (structural and MEP), 19% were builders, and 11% were BIM specialists or consultants. About 65% of the respondents had over five years of professional experience, and 71% were members of professional regulatory bodies such as ARCON, COREN, NIOB, and ACEN.

Professional Background	Percentage (%)
Architects	41
Engineers	29
Builders	19
BIM Specialists	11



Only 29% of respondents indicated that they had used BIM in climate-responsive design contexts. Among these, daylight analysis and ventilation modelling were the most cited applications. However, less than 15% had used BIM tools to simulate thermal mass or passive solar design, suggesting a gap in advanced BIM application knowledge.

Respondents identified several barriers to adoption:

- Technical Barriers: 71% reported a lack of trained personnel.
- Financial Constraints: 64% cited high initial software and training costs.
- Policy and Institutional Challenges: 59% indicated the absence of national or state-level BIM mandates or incentives.

Furthermore, 52% of respondents believed that the academic curriculum in Nigerian universities does not adequately prepare graduates for BIM-based practices.

Respondents recommended:

- Increased professional training and certification (76%)
- Government-backed BIM adoption policies (69%)
- Inclusion of BIM in architectural and engineering education curricula (62%)
- Development of localised BIM standards and climate-responsive toolkits (47%)

3. Discussion

These findings reflect the growing awareness but limited application of BIM in climate-responsive architecture across South-West Nigeria. The disparity between awareness and practical use underscores the need for structured training and policy support. Similar findings were reported by Olugboyega, Oseghale, and Aigbavboa, who highlighted a skills and application gap despite increasing BIM awareness in Nigeria [2]. The underutilisation of BIM for passive design strategies (e.g., solar orientation, thermal mass optimisation) reveals that most professionals still rely on traditional CAD tools and conventional design methods. This supports recent claims by Wang, Abdul-Samad, and Salleh (2024), who noted that although BIM has the potential to enhance green building performance, its implementation is often limited to visualisation and documentation in developing economies.

The higher adoption rates in Lagos and Ogun can be attributed to the concentration of multinational firms and greater access to training facilities in those states. These regional differences suggest that targeted policy interventions and investment in capacity-building infrastructure are critical, especially for underserved areas like Ekiti and Osun. The findings also emphasise the role of government policy in driving BIM adoption. The absence of a mandatory BIM execution plan or state-backed incentive schemes discourages firms from transitioning. This aligns with observations made by Oke, Aigbavboa, and Olatunji, who called for urgent policy reforms to stimulate sustainable building practices in Nigeria [1]. In terms of climate-responsive design, BIM's integration remains superficial. A shift from basic modelling to performance-based design is necessary. Tools like Revit Insight, Design Builder, and Climate Studio should be promoted for use in thermal comfort analysis and energy modelling. Adoption of such tools can significantly enhance compliance with Nigeria's National Climate Change Policy [25]. In conclusion, improving BIM adoption in South-West Nigeria for climate-responsive architecture demands a multi-pronged strategy involving policy support, professional training, curriculum reform, and access to affordable tools. These changes are vital to realising Nigeria's vision of a sustainable, climate-adaptive built environment.

4. Recommendations and Conclusion

Based on the findings of this study, several strategies are recommended to enhance the adoption of Building Information Modelling (BIM) in climate-responsive architecture across South-West Nigeria. First, there is a critical need for targeted training programmes and capacity-building initiatives tailored to architects, engineers, and builders to strengthen their BIM proficiency, particularly in its application for sustainable design. Professional bodies such as NIA, COREN, and NIOB should integrate BIM-focused sustainability modules into their continuing professional development frameworks. Furthermore, government agencies should develop supportive policies that mandate

BIM use in public building projects while offering incentives, such as tax rebates or grants, to private developers who adopt BIM for energy-efficient and climate-adaptive buildings. In conclusion, the integration of BIM into climate-responsive architecture presents a significant opportunity to address the energy and environmental challenges facing South-West Nigeria. This study has shown that while awareness of BIM is relatively high, its actual application in passive and sustainable building design remains limited due to various institutional, technical, and policy-related barriers. Addressing these issues through strategic interventions will be key to achieving a digitally-enabled, climate-resilient built environment in the region. A collaborative effort among stakeholders—including government, academia, and the private sector is essential to realising the full potential of BIM in promoting sustainable architectural practices in Nigeria.

References

1. Wodike, O. O., & Ejuh, G. O. Relevance of Building Information Modelling (BIM) to Sustainable National Development in Nigeria.
2. Olugboyega, O., Oseghale, G. E., & Aigbavboa, C. (2023). Multiple holistic case study of project-level building information modelling (BIM) adoption in Nigeria. *Construction Innovation, 23*(3), 567-586.
3. Akinola, A. A., Adedire, F. M., & Alagbe, O. A. (2023). Adoption of Building Information Modeling (BIM) in Architectural Firms in Ibadan, Southwest Nigeria. *ATBU Journal of Environmental Technology, 16*(1), 99-117.
4. Umana, A. U., Garba, B. M. P., Ologun, A., Olu, J. S., & Umar, M. O. (2024). Architectural design for climate resilience: Adapting buildings to Nigeria's diverse climatic zones. *World Journal of Advanced Research and Reviews, 23*(03), 397-408.
5. Amade, B., Ononuju, C. N., Moneke, U. U., Okorie, C. E., & Adeyemo, A. A. (2021). A Survey on the status of Building Information Modeling's (BIM) adoption. *PM World Journal, 10*(8), 1-15.
6. Abubakar, N., Ibrahim, Y., Kado, D., & Bala K. (2022). Building Information Modelling (BIM) adaptation in Nigeria: current stats and future direction. *Journal of Construction in Developing Countries, 7*(1), 83-104.
7. Luo, R. (2025). Utilization of sustainable BIM technology based on the Internet of Things in construction projects. *Journal of Engineering and Applied Science, 72*(1), 46.
8. Wong, P., Ge, J., &He, L. (2023). AI-assisted Building Information Modelling and GIS for Smart Urban Planning. *Cities, 128*, 103748
9. Zhao, J., Li, W., & Zhang, X. (2022). IoT-based BIM platform for real-time energy management in smart buildings. *Journal of Cleaner Production, 372*, 133682
10. Sharma, A., & Tyagi, V. V. (2021). Climate responsive architecture: A review. *Energy and Buildings, 249*, 111257.
11. Wang, R., Abdul-Samad, Z., & Salleh, H. (2024). Systematic literature review of BIM application in the whole life cycle of green building projects. *Advances in Building Energy Research, 18*(5), 495-532.
12. GhaffarianHoseini, A., Tookey, J., GhaffarianHoseini, A., Naismith, N., & Rowlinson, S. (2023). Building Information Modelling (BIM) in design, construction and operations of green buildings: A systematic review. *Renewable and Sustainable Energy Reviews, 150*, 111414.
13. Alwan, Z., & Jones, P. (2014). The importance of embodied energy in carbon footprint assessment. *Structural survey, 32*(1), 49-60.
14. Numa, M., Saadat, U., & Farooq, M. U. (2024). BIM and sustainable design: A review of strategies and tools for green building practices. *Journal of Engineering Research and Sciences, 3*(2), 1-7.
15. Azhar, S., Khalfan, M., & Maqsood, T. (2012). Building information modeling (BIM): now and beyond. *Australasian Journal of Construction Economics and Building, The, 12*(4), 15-28.
16. Onyenokporo, N., & Oke, A. (2023). Leveraging BIM for environmental sustainability in residential housing: A Nigerian perspective. *Journal of Environmental Design and Management, 5*(1), 44-59.
17. Eshraghi, P., Talami, R., Dehnavi, A. N., Mirdamadi, M., & Zomorodian, Z. S. (2025). Adopting explainable-AI to investigate the impact of urban morphology design on energy and environmental performance in dry-arid climates. *Advances in Building Energy Research, 1*-35.
18. Rezaei, M., Shokry, F., & Mohammadi, A. (2023). Urban BIM for climate-sensitive city planning: A performance-based microclimate approach. *Sustainable Cities and Society, 92,* 104430.
19. Xie, X., Wang, M., & Shen, G. O. (2022). Integrating BIM and GIS for smart urban planning. *Cities, 128*, 103748
20. Okereke, P. A., Nwachukwu, O. A., & Ugwu, E. I. (2023). Barriers to BIM adoption in Nigeria's built environment: A stakeholder analysis. *Journal of Building and Management Studies, 14*(1), 24-38.
21. Agboola, A., Ojelabi, R., & Oyedele, L. (2024). Digitalisation in Nigerian Construction: A critical review of BIM integration in sustainable development. *Journal of Building Performance, 15*(2), 67-80.
22. Okafor, M., Ezeh, C., & Ude, I. (2023). Policy gaps and digital transformation in Nigeria's AEC sector: A BIM perspective. *Construction Innovation Journal, 23*(4), 410-428.
23. Adeniran, T., & Adedeji, Y. (2022). Capacity challenges in implementing BIM in Nigerian Construction Projects. *Journal of Sustainable Built Environment, 10*(3), 124-135.
24. Fapohunda, J. A., & Mushunje, M. T. (2024). Educational integration of BIM into Architecture curricula in Nigeria: Challenges and prospects. *Journal of Architectural Education in Africa, 8*(1), 12-25.
25. Federal Ministry of Environment (2021). National Climate Change Policy for Nigeria. Abuja: Government Press.
26. ECREEE (2022). Renewable energy and energy efficiency status report for Nigeria. *Economic Community of West African States.*
27. Oke, A., Alabi, S., & Falade, O. (2024). Advancing BIM-based sustainability practices in Nigeria's construction industry. *Journal of Sustainable Architecture and Civil Engineering, 34*(2), 55-68.