© JUL 2026 | IRE Journals | Volume 10 Issue 1 | ISSN: 2456-8880
DOI: https://doi.org/10.64388/IREV10I1-1719816

AI-Assisted Passive Design Strategies for Climate-Responsive Affordable Housing in Nigeria: A Systematic Literature Review and Conceptual Framework

HARRISON E. OKULA
Department of Architectural Technology, Federal Polytechnic, Ado-Ekiti, Nigeria.

Abstract- The increasing demand for affordable housing, environmental concerns, and rapid urbanization have increased the need for sustainable design solutions in developing countries. The conventional housing design in Nigeria is often not climatically responsive, which leads to excessive operational energy consumption and reduced indoor thermal comfort. Artificial Intelligence (AI) provides new opportunities to improve early-stage design decisions, enabling passive strategies that reduce environmental impacts while maintaining affordability. This paper presents a Systematic Literature Review (SLR) on the potential of AI-assisted passive design strategies for climate-responsive affordable housing in Nigeria. The review discusses the most used technologies for optimizing building orientation, natural ventilation, daylighting, solar shading and material selection: machine learning, generative design, predictive analytics, artificial neural networks, and AI-integrated Building Information Modeling (BIM). Research activity is expanding globally but little evidence exists related to affordable housing in tropical developing countries. Based on the review results, the research proposes an AI-assisted passive design framework to integrate climate and site data, AI-based design analysis, passive design optimization, building performance evaluation and iterative decision support. The framework offers architects, housing developers, and policymakers a systematic approach to improve energy efficiency, occupant comfort, and climate resilience in affordable housing. The study contributes to the practice of sustainable architecture by demonstrating how AI can improve climate-responsive design and contribute to the general goals of digital innovation and sustainable development in Nigeria's built environment.

Keywords: Artificial Intelligence; Passive Design; Climate-Responsive Housing; Affordable Housing; Sustainable Architecture; Nigeria; Systematic Literature Review

I. INTRODUCTION

The building industry is a major part of energy use and greenhouse gases and resource depletion and thus an important part of the global sustainability goals. Buildings account for about 37% of global energy-related carbon dioxide emissions (United Nations Environment Programme (UNEP, 2023)), emphasizing the necessity of more sustainable design approaches. Furthermore, climate change has exacerbated environmental problems like rising temperatures, extreme weather events, and increasing energy demand, especially in developing countries (Intergovernmental Panel on Climate Change [IPCC, 2023]). These challenges have revived interests in climate- responsive architecture as a means to improve building performance while reducing environmental impacts.

Passive design is recognized as one of the most effective ways of improving the sustainability of buildings. Passive design is the response to the local climatic conditions through proper building orientation, natural ventilation, daylight optimization, solar shading, thermal mass, and material selection to achieve occupant comfort and minimize the need for mechanical heating and cooling. (Givoni, 1998; Olgyay, 2015; Lechner, 2015). Passive strategies are incorporated in the early stages of design, making them cost-effective solutions for reducing operational energy demand and improving long-term environmental performance.

Thanks to AI's recent impressive advancements, architects can now more efficiently evaluate complex environmental data sets and optimize design alternatives, opening up new possibilities for passive

© JUL 2026 | IRE Journals | Volume 10 Issue 1 | ISSN: 2456-8880
DOI: https://doi.org/10.64388/IREV10I1-1719816

design. Artificial intelligence technologies such as machine learning, artificial neural networks, predictive analytics, generative design, and AI-integrated Building Information Modeling (BIM) enable quick assessment of multiple design options and prediction of important performance metrics like energy consumption, daylight availability, thermal comfort, natural ventilation, and carbon emissions (Rane & Nitin 2023). The purpose of these technologies is not to replace architects but to support their professional decision-making by evidence-based analysis and improved design optimization.

In Nigeria, where the built environment is under a lot of stress from rapid urbanization, population growth, housing shortages, unstable electricity supply, and rising temperatures (World Bank, 2023; Akande, O. 2010), adding AI to passive design is especially important. Although affordable housing is still a national priority, many residential developments fail to adapt to local climate conditions, which leads to poor thermal comfort, excessive energy use, and increased operating costs. It is possible to make housing more affordable and better for the environment with AI-assisted passive design (Piragash et al., 2025) by helping designers make decisions that are appropriate for Nigeria's different climate zones.

Significant information gaps persist despite the increasing amount of studies on artificial intelligence (AI) in sustainable building design and architecture. There has been a dearth of focus on affordable, climate-responsive housing in developing nations, as most of the prior research has focused on commercial or high-performance structures in developed countries. (Miracle et al., 2026). Additionally, there are few studies that integrate AI technologies, passive design strategies, and building performance assessment into a single framework suitable for architectural practice in Nigeria. This gap restricts the practical application of AI as a decision-support tool for sustainable housing design.

To address these gaps, this study conducts a systematic literature review of AI applications in passive design and sustainable architecture. Additionally, it proposes an AI-assisted passive design framework for climate-responsive affordable housing in Nigeria. This framework integrates climate and site analysis, AI-assisted design evaluation, passive design optimization, and building performance assessment into a structured workflow that assists architects during the early stages of design.

The objectives of the study are to: (1) review current applications of AI in passive architectural design; (2) identify AI technologies that enhance climate-responsive and affordable housing design; (3) examine the challenges associated with AI adoption in sustainable architecture; and (4) develop a conceptual framework that supports evidence-based architectural decision-making in Nigeria. The results support architectural research and practice by demonstrating how AI can strengthen climate-responsive passive design while advancing sustainable, affordable, and resilient housing in line with the Sustainable Development Goals (United Nations, 2015).

II. RESEARCH METHODOLOGY

2.1 Research Design

To evaluate the application of artificial intelligence (AI) in passive design strategies for climate-responsive-affordable housing in Nigeria, this study adopted a systematic literature review (SLR). A systematic literature review (SLR) gives a systematic, transparent, and replicable approach to identify, evaluate, and synthesize existing evidence, reducing the selection bias and increasing the reliability of the study results. (Tranfield et al., 2003). In contrast to conventional narrative reviews, the systematic review approach adheres to predetermined protocols that enhance methodological consistency and facilitate the synthesis of evidence-based knowledge.

The review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines (Page et al., 2021). After exporting all retrieved records to the reference manager, duplicate entries were removed before conducting a two-stage screening process consisting of title/abstract review followed by full text eligibility assessment.

© JUL 2026 | IRE Journals | Volume 10 Issue 1 | ISSN: 2456-8880
DOI: https://doi.org/10.64388/IREV10I1-1719816

The primary objectives of the review were to:
1. identify current AI applications supporting passive architectural design;
2. examine AI technologies that improve climate-responsive and affordable housing;
3. analyze challenges limiting AI adoption in sustainable architectural practice; and
4. synthesize existing knowledge to develop an AI-assisted passive design framework suitable for Nigeria's climatic and socio-economic context.

2.2 Search Strategy

A thorough literature search was carried out in six important databases, viz., Scopus, Web of Science, ScienceDirect, IEEE Xplore, Google Scholar, and Taylor & Francis Online. These databases were chosen for their comprehensive coverage of research in the fields of architecture, engineering, construction, sustainability, artificial intelligence, and the built environment.

The search strategy combined keywords with Boolean operators to maximize retrieval of relevant studies while reducing irrelevant records. Typical search expressions included:
- ("Artificial Intelligence" OR "Machine Learning" OR "Deep Learning") AND Architecture
- ("Artificial Intelligence" OR AI) AND ("Passive Design" OR "Passive Cooling")
- ("Machine Learning" OR "Artificial Neural Network") AND "Building Performance"
- "Climate-Responsive Housing" AND Sustainability
- ("Affordable Housing") AND ("Artificial Intelligence" OR AI)
- ("Building Information Modeling" OR BIM) AND AI

Searches were restricted to peer-reviewed journal articles, conference proceedings, review papers, and authoritative institutional reports published in English. Most of the research materials are recent publications to capture the rapid development of AI technologies and their increasing application within architectural design and sustainable construction.

To improve completeness, reference lists of key publications were manually examined to identify additional relevant studies that were not captured through database searches.

2.3 Study Selection

The study selection procedure followed the four stages recommended by the PRISMA 2020 framework: identification, screening, eligibility, and inclusion (Page et al., 2021).

Initially, duplicate publications were identified and eliminated after all retrieved records were exported into a reference management system. The relevance of the remaining records to the review objectives was evaluated through title and abstract screening. Studies that met the criteria for the preliminary screening were then evaluated in full text to assess their eligibility.

Studies were included if they:
- investigated AI applications within architecture, engineering, or sustainable building design;
- examined passive design strategies, climate-responsive architecture, building performance, or affordable housing;
- reported empirical investigations, simulation studies, systematic reviews, or recognized conceptual contributions; and
- provided sufficient methodological detail to support meaningful interpretation.

Studies were excluded if they:
- focused on disciplines unrelated to the built environment;
- addressed AI applications without architectural relevance;
- lacked adequate methodological information;
- were editorials, opinion articles, or non-peer-reviewed publications; or
- were unavailable in English.

Following the application of these criteria, 31 studies were retained for qualitative synthesis. The complete selection process is summarized in Table 2.1.

© JUL 2026 | IRE Journals | Volume 10 Issue 1 | ISSN: 2456-8880
DOI: https://doi.org/10.64388/IREV10I1-1719816

Table 2.1 PRISMA Study Selection Process

Stage	Number of Records
Records identified through database searching (Scopus, Web of Science, Google Scholar, ScienceDirect, SpringerLink)	214
Duplicate records removed	41
Records screened	173
Records excluded after title/abstract screening	109
Full-text articles assessed for eligibility	64
Full-text articles excluded	33
Studies included in qualitative synthesis	31

2.4 Quality Appraisal
A quality appraisal was conducted on each eligible study to guarantee the credibility and reliability of the synthesized evidence, based on four assessment criteria:

- relevance to the research objectives;
- methodological clarity and transparency;
- credibility of data sources and analytical procedures; and
- contribution to AI-assisted passive design and sustainable housing research.

Priority was given to peer-reviewed journal publications indexed in reputable databases, while authoritative reports from internationally recognized organizations were included where appropriate. The use of multiple databases reduced publication bias and improved the comprehensiveness of the review.

2.5 Data Extraction
Relevant information from each selected study was extracted using a standardized data extraction template to ensure consistency throughout the review process. The extracted information included:

- publication year;
- country or geographical focus;
- research objectives;
- AI technologies employed;
- passive design strategies investigated;
- research methodology;
- software or simulation tools used; and
- principal findings and identified limitations.

The extracted data enabled systematic comparison across studies and facilitated the identification of recurring research patterns, emerging trends, and existing knowledge gaps.

2.6 Data Analysis and Synthesis
The studies that were extracted were examined using thematic analysis, a method of qualitative synthesis that is well-suited to discovering commonalities and connections among diverse bodies of literature.
Following the approach recommended by Snyder (2019), studies with similar findings were grouped into broader thematic categories.

Five principal themes emerged from the synthesis:

- AI applications in architectural design;
- passive design optimization;
- climate-responsive affordable housing;
- sustainability and building performance outcomes; and
- barriers to AI implementation.

Thematic synthesis facilitated the comparison of diverse studies and underscored the areas in which evidence is still insufficient, particularly in the context of affordable housing in developing countries. The findings also formed the basis for the analysis for the development of the proposed conceptual framework.

2.7 Development of the Conceptual Framework
The systematic literature review generated the evidence that directly informed the development of the AI-assisted passive design framework proposed in this study. Following the thematic synthesis, the framework structure was developed by integrating climate and site analysis, AI-assisted environmental evaluation, passive design optimization, building performance assessment, and iterative decision support into a continuous architectural workflow.

The framework is conceptual, not software-specific. The purpose of this document is to assist architects, housing developers, researchers, and policymakers in making evidence-based design decisions that improve the energy efficiency, thermal comfort, climate

© JUL 2026 | IRE Journals | Volume 10 Issue 1 | ISSN: 2456-8880
DOI: https://doi.org/10.64388/IREV10I1-1719816

resilience, and affordability of residential developments in Nigeria. The framework offers a practical decision-support model for enhancing sustainable architectural practice in developing country contexts by integrating AI technologies and passive architectural strategies.

III. LITERATURE REVIEW

3.1 Artificial Intelligence in Architecture and the Built Environment

By enhancing design efficiency, prediction, and decision-making, artificial intelligence (AI) has emerged as a transformative technology in the Architecture, Engineering, and Construction (AEC) sector. AI is a collection of computational techniques, including generative design, natural language processing, computer vision, deep learning, and machine learning, that allow architects to analyze environmental data, predict building performance, and optimize design alternatives (Dileep et al., 2025; Lere & Bilkisu, 2025; Albukhari, 2025). AI applications have been expanded through integration with Building Information Modeling (BIM) and digital twins to support automated design evaluation, lifecycle analysis, and real-time performance monitoring (Rane & Nitin 2023; Fan et al., 2022). In spite of these developments, the adoption of AI in developing countries is still restricted by a lack of financial resources, digital infrastructure, and AI expertise (Akram et al., 2025).

Synthesis: AI has significantly enhanced design optimization and evidence-based decision-making, yet its application to affordable housing in tropical developing countries remains limited.

3.2 Passive Design Strategies for Sustainable Residential Buildings

Passive design lowers the energy consumption of buildings by adapting to the local climate through architectural decisions made during the initial design phases (Givoni, 1998; Lechner, 2015; Olgyay, 2015). Sommasse key strategies are appropriate building orientation, natural ventilation, daylight optimization, solar shading, thermal mass, and choice of climate-responsive materials. Research suggests that these measures improve indoor thermal comfort and reduce the need for mechanical cooling, particularly in hot climates. (Tahan et al., 2026; Kushwaha & Gupta, 2026) Building performance simulation enhances passive design by allowing architects to assess energy consumption, daylight, and ventilation prior to construction (Negendahl, 2015).

Synthesis: Passive design remains fundamental to sustainable architecture, but its effectiveness depends on accurate climatic analysis and iterative performance evaluation, creating opportunities for AI-assisted optimization.

3.3 Climate-Responsive Affordable Housing in Nigeria

Climate-responsive housing is designed to enhance environmental performance while simultaneously ensuring the well-being and affordability of its occupants. Nigeria has experienced rising demand for sustainable residential design due to rapid urbanization, high temperatures, unreliable electricity supply, and housing shortages (Garba et al., 2024; World Bank, 2023). By incorporating biophilic design, environmental quality and occupant well-being are further enhanced (Adamolekun, 2026), while passive design strategies can significantly improve thermal comfort and reduce household energy expenditure (Ming et al., 2023; Kambari et al., 2025). Nevertheless, implementation is still hindered by inadequate digital infrastructure, limited technical expertise, and weak policy enforcement.

Synthesis: Although climate-responsive housing offers considerable environmental and social benefits, passive design principles are not yet consistently incorporated into affordable housing practice in Nigeria.

3.4 AI-Assisted Passive Design Optimization

AI has enhanced passive design by facilitating the rapid analysis of environmental variables and the optimization of building orientation, ventilation, daylighting, shading, and material selection (Chew et al., 2024). Machine learning, artificial neural networks, and generative design enhance the accuracy of predictions, while AI-integrated BIM and digital twins facilitate the evaluation of lifecycle performance (Negendahl, 2015).

© JUL 2026 | IRE Journals | Volume 10 Issue 1 | ISSN: 2456-8880
DOI: https://doi.org/10.64388/IREV10I1-1719816

Synthesis: AI-assisted passive design has advanced considerably, but its application to climate-responsive affordable housing in developing countries remains underexplored.

3.5 Challenges to AI Adoption in Sustainable Architecture

There are technical, economic, and institutional barriers to the implementation of AI in architecture. However, limited access to high-quality datasets, software interoperability issues, implementation costs, and shortages of AI-skilled professionals continue to hinder wider application (Ismail et al., 2024). Moreover, the regulatory frameworks and professional education have not yet been fully adapted to support AI-assisted architectural practice in Nigeria.

Synthesis: Overcoming technical, educational, and policy barriers will be essential for mainstream adoption of AI-assisted passive design.

3.6 Synthesis and Research Gap

The literature review indicates that AI technologies, passive design strategies, and climate-responsive housing have each garnered significant scholarly attention. AI enhances predictive modeling and design optimization, and passive design improves energy efficiency and occupant comfort. However, there are three major gaps. First, there are no studies that explicitly connect AI-assisted decision-making and passive design strategies for affordable housing. Secondly, most of the research is from developed economies; hence, its application to Nigeria and other similar developing countries is limited. Third, there are still few comprehensive frameworks that integrate climate data, AI technologies, passive design principles, and building performance assessment.

This study proposes an AI-assisted passive design framework for climate-responsive affordable housing in Nigeria, which synthesizes current evidence and addresses these gaps. To encourage sustainable architectural practices, the framework offers a context-specific decision-support model that combines passive design strategies with AI technologies.

IV. RESULTS OF THE SYSTEMATIC LITERATURE REVIEW

4.1 Overview of the Selected Studies

The systematic literature review followed the PRISMA 2020 framework to ensure a transparent and reproducible study selection process (Page et al., 2021). Publications addressing artificial intelligence (AI), passive design, sustainable architecture, climate-responsive housing, and affordable housing were identified through database searches, screened using predefined inclusion and exclusion criteria, and subjected to full text review before qualitative synthesis.

The selected studies demonstrate the rapid growth of AI applications within the Architecture, Engineering, and Construction (AEC) industry. Most research focused on building performance optimization, energy efficiency, and computational decision support, whereas comparatively few studies addressed affordable housing in tropical developing countries.

4.2 Characteristics of the Reviewed Studies

Analysis of the reviewed literature revealed three key trends. First, publications increased significantly after 2020, reflecting growing interest in AI-driven sustainable building design enabled by advances in machine learning, generative design, and Building Information Modeling (BIM) (Chew et al., 2024; Manmatharasan et al., 2025). Second, most studies originated from Europe, North America, and Asia, with limited contributions from Africa, particularly Nigeria. Third, quantitative simulation, optimization, and computational modeling were the dominant research methods, while qualitative studies addressing implementation and policy remained relatively scarce.

Table 4.1 Characteristics of Reviewed Studies

Characteristic	Observation
Publication period	Majority published between 2020 and 2025
Geographic focus	Europe, Asia, and North America dominate.

© JUL 2026 | IRE Journals | Volume 10 Issue 1 | ISSN: 2456-8880
DOI: https://doi.org/10.64388/IREV10I1-1719816

African studies	Limited representation
Research methods	Simulation, modeling and optimization
Common building type	Commercial and institutional buildings
Affordable housing studies	Comparatively few
Dominant software	BIM, EnergyPlus, Rhino–Grasshopper, and AI optimization tools

These findings indicate that AI research has expanded rapidly, although affordable housing remains an underrepresented application area.

4.3 Emerging Research Themes

Five major themes emerged from the thematic synthesis:

1. AI-driven building performance prediction: Machine learning models were widely used to predict energy consumption, thermal comfort, daylight availability, and carbon emissions, supporting informed design decisions (Tang & Karadag, 2026).
2. Generative design and optimization: AI-enabled generative design allowed architects to automatically evaluate multiple design alternatives while improving energy efficiency, daylighting, spatial functionality, and cost performance (Chew et al., 2024).
3. Integration with BIM: AI-enhanced BIM supported automated design evaluation, lifecycle analysis, clash detection, and performance optimization throughout the design process (Abbasnejad et al., 2026).
4. Climate-responsive passive design: AI-assisted optimization improved building orientation, natural ventilation, solar shading, daylight utilization, and material selection, leading to enhanced energy efficiency and occupant comfort (Negendahl, 2015).
5. Sustainability and climate resilience: AI-assisted passive design contributed to lower energy demand, reduced greenhouse gas emissions, lower lifecycle costs, and improved climate resilience (Yang, 2025).

4.4 AI Technologies Applied in Passive Design

The review identified several AI technologies that support passive design optimization.

Table 4.2 Major AI Technologies Identified

AI Technology	Primary Application	Expected Benefit
Machine Learning	Energy prediction	Improved building performance
Artificial Neural Networks	Thermal comfort modeling	Greater prediction accuracy
Generative Design	Design optimization	Faster exploration of alternatives
Predictive Analytics	Environmental forecasting	Better design decisions
AI-Integrated BIM	Building lifecycle analysis	Improved coordination and efficiency
Digital Twins	Real-time performance monitoring	Continuous optimization

Machine learning and generative design were the most frequently reported technologies because of their ability to analyze large climatic datasets, predict environmental performance, and evaluate numerous passive design alternatives efficiently.

4.5 Challenges and Research Gaps

Despite the growing potential of AI-assisted passive design, researchers identified several recurring challenges. Technical barriers include limited availability of high-quality climatic datasets, software interoperability issues, and computational complexity. Economic constraints include high implementation costs and limited access to advanced digital technologies, particularly for smaller architectural firms. Institutional challenges involve inadequate AI expertise, limited integration of AI into architectural education, and weak policy support for digital innovation.

© JUL 2026 | IRE Journals | Volume 10 Issue 1 | ISSN: 2456-8880
DOI: https://doi.org/10.64388/IREV10I1-1719816

4.6 Summary of Key Findings
The review demonstrates that AI has become an important tool for improving sustainable architectural design through data-driven decision-making and passive design optimization. Machine learning, generative design, predictive analytics, AI-integrated BIM, and digital twins have significantly enhanced architects' ability to evaluate building performance during the early design stages.

However, an important research gap remains. While AI applications are well established in commercial and high-performance buildings, comparatively little research has focused on climate-responsive affordable housing in tropical developing countries such as Nigeria. This gap provides the basis for the AI-assisted passive design framework proposed in the following section.

V. PROPOSED AI-ASSISTED PASSIVE DESIGN FRAMEWORK FOR CLIMATE-RESPONSIVE AFFORDABLE HOUSING IN NIGERIA

5.1 Introduction to the Proposed Framework
The systematic literature review demonstrated that artificial intelligence (AI) has considerable potential to improve sustainable architectural design through enhanced environmental analysis, predictive modeling, and passive design optimization. However, the review also revealed a significant gap in integrating AI technologies with climate-responsive affordable housing in developing countries such as Nigeria. While previous studies have examined AI applications, passive design, and sustainable housing independently, relatively few have combined these concepts into a unified architectural decision-support framework (Chew et al., 2024; Manmatharasan et al., 2025).

To address this gap, this study proposes an AI-assisted passive design framework for climate-responsive affordable housing in Nigeria. The framework integrates climate and site analysis, AI-assisted design evaluation, passive design optimization, and building performance assessment into a continuous workflow that supports architects during the conceptual design stage. Rather than replacing professional judgment, AI functions as an intelligent decision-support tool that enhances evidence-based design and sustainability outcomes.

5.2 Framework Components
The proposed framework comprises five interconnected stages that establish an iterative and evidence-based architectural design process.

Stage 1: Climate and Site Data Acquisition
The process begins with collecting project-specific and environmental information, including climatic variables (temperature, humidity, solar radiation, wind direction, and rainfall), site characteristics, project requirements, and relevant building regulations. These inputs provide the foundation for climate-responsive design and are particularly important in tropical environments where orientation and ventilation strongly influence building performance (Givoni, 1998; Lechner, 2015).

Stage 2: AI-Assisted Design Analysis
Environmental data are analyzed using AI technologies such as machine learning, artificial neural networks, predictive analytics, generative design, and AI-integrated Building Information Modeling (BIM). These tools enable architects to evaluate multiple design alternatives and predict indicators such as energy consumption, thermal comfort, daylight availability, natural ventilation, and carbon emissions. Compared with conventional manual methods, AI improves the speed, consistency, and accuracy of early-stage design evaluation.

Stage 3: Passive Design Optimization
Based on AI-generated insights, passive design strategies are refined to improve building performance. Key variables include building orientation, window-to-wall ratio, natural ventilation, solar shading, daylight utilization, thermal mass, roof configuration, building envelope performance, and climate-responsive material selection. The optimization process is iterative, allowing architects to compare alternatives until acceptable

environmental and sustainability performance is achieved.

Stage 4: Building Performance Assessment
The optimized design is evaluated using AI-enabled simulation tools and BIM-based performance assessment. Indicators include annual energy demand, thermal comfort, daylight autonomy, natural ventilation efficiency, carbon emissions, lifecycle operating costs, and occupant comfort. This stage verifies whether the proposed design satisfies sustainability objectives before detailed design and construction. International standards such as ISO 52016-1 provide useful benchmarks for assessing building energy performance.

Stage 5: Decision Support and Continuous Improvement
The final stage uses performance results to support informed decision-making by architects and other stakeholders. Where performance targets are not achieved, feedback is incorporated into subsequent design iterations, enabling continuous refinement before construction. This iterative approach ensures that AI supports, rather than replaces, the architect's professional expertise and creative judgement.

5.3 Expected Outcomes

The proposed framework is expected to generate significant environmental, economic, social, and professional benefits. Environmentally, it supports reduced operational energy use, lower greenhouse gas emissions, improved thermal comfort, enhanced natural ventilation, and better daylight utilization. Economically, it contributes to reduced lifecycle costs, greater affordability, and more efficient resource use. Socially, the framework promotes improved indoor environmental quality, healthier living conditions, and more resilient housing. Professionally, it encourages evidence-based decision-making, greater integration of AI into architectural practice, enhanced design efficiency, and stronger interdisciplinary collaboration.

5.4 Conceptual Representation of the Framework

The framework can be represented as a linear workflow linking climate and site data acquisition, AI-assisted design analysis, passive design optimization, building performance assessment, and decision support. A continuous feedback loop connects performance evaluation to earlier design stages, enabling iterative refinement and improved sustainability outcomes before construction.

5.5 Significance of the Proposed Framework

The proposed framework represents the principal contribution of this study by integrating AI technologies, passive design strategies, and climate-responsive affordable housing within a single decision-support model tailored to the Nigerian context. Unlike previous studies that address these themes separately, the framework provides a structured workflow linking environmental analysis, AI-driven optimization, passive design principles, and performance evaluation.

The framework has practical value for architects, housing developers, policymakers, and educators by supporting evidence-based design decisions, encouraging the adoption of digital technologies, and informing professional training and housing policies. Its emphasis on climate responsiveness and energy efficiency also aligns with the achievement of Sustainable Development Goals (SDGs) 7 (Affordable and Clean Energy), 11 (Sustainable Cities and Communities), and 13 (Climate Action) (United Nations, 2015). Accordingly, the framework provides a practical foundation for advancing sustainable and affordable housing while strengthening climate resilience within Nigeria's built environment.

VI. DISCUSSION

The findings of this systematic literature review demonstrate that artificial intelligence (AI) has considerable potential to transform sustainable architectural design by enhancing the application of passive design strategies during the early stages of building development. The reviewed studies consistently indicate that AI technologies—including machine learning, generative design, predictive analytics, artificial neural networks, and AI-integrated Building Information Modeling (BIM)—

© JUL 2026 | IRE Journals | Volume 10 Issue 1 | ISSN: 2456-8880
DOI: https://doi.org/10.64388/IREV10I1-1719816

enable architects to evaluate multiple design alternatives efficiently while improving energy performance, thermal comfort, and environmental sustainability (Chew et al., 2024; Manmatharasan et al., 2025). These findings reinforce the growing recognition that AI should be viewed as an intelligent decision-support tool that complements, rather than replaces, professional architectural expertise.
A key finding of this review is the strong relationship between AI-assisted optimization and passive design performance. Across the reviewed studies, AI significantly improved the evaluation of building orientation, natural ventilation, daylight utilization, solar shading, and material selection, resulting in more climate-responsive and energy-efficient building designs. Rajput and Thomas (2022) demonstrated that computational optimization can substantially improve passive design outcomes compared with conventional manual approaches.

Despite these technological advances, the review also identified an important imbalance within the existing literature. Most AI applications have been developed and tested in commercial buildings, institutional facilities, or high-income countries, whereas comparatively little attention has been given to affordable housing in tropical developing contexts. This geographical and sectoral imbalance limits the transferability of existing knowledge to countries such as Nigeria, where climatic conditions, housing affordability, digital infrastructure, and professional practice differ significantly from those of developed economies. The proposed framework addresses this gap by integrating AI-assisted decision-making with passive design strategies in a manner that is specifically tailored to climate-responsive affordable housing.

The findings also have important implications for professional practice and policy. For architects, the framework provides a structured workflow that supports evidence-based design decisions while preserving creativity and professional judgment. Policymakers can facilitate wider adoption by promoting digital capacity building, strengthening sustainable building regulations, encouraging AI integration within the construction sector, and supporting investment in climate-responsive housing initiatives.

VII. CONCLUSION AND RECOMMENDATIONS

7.1 Conclusion
This study examined the role of artificial intelligence (AI) in enhancing passive design strategies for climate-responsive affordable housing through a systematic literature review. The findings demonstrate that AI technologies—including machine learning, artificial neural networks, generative design, predictive analytics, and AI-integrated Building Information Modeling (BIM)—can significantly improve environmental analysis, building performance prediction, and passive design optimization (Chew et al., 2024). However, the review identified a significant research gap in applying these technologies to affordable housing within developing countries, particularly Nigeria.

To address this gap, the study proposed an AI-assisted passive design framework integrating climate and site analysis, AI-assisted design evaluation, passive design optimization, building performance assessment, and decision support into a structured workflow. The framework provides architects with a practical decision-support model for improving energy efficiency, thermal comfort, and sustainability while promoting climate-responsive affordable housing.

The study contributes to sustainable architectural research by synthesizing current evidence and presenting a context-specific framework for Nigeria. Nevertheless, its findings are based on secondary data and require empirical validation through practical application.

7.2 Recommendations
Future studies should validate the proposed framework using building performance simulations and real-world case studies across Nigeria's climatic regions. Architectural schools and professional bodies should strengthen AI and digital design training to improve practitioners' capacity. Policymakers should encourage the adoption of AI-

supported sustainable design through updated building regulations and incentives, while future research should compare the framework with conventional design approaches to evaluate its effectiveness in improving energy efficiency, occupant comfort, and affordability.

Overall, integrating AI with passive design provides a promising pathway for delivering sustainable, affordable, and climate-resilient housing and supports the achievement of Sustainable Development Goals 7, 11, and 13 (United Nations, 2015).

REFERENCES

[1] Abbasnejad, B., Ahankoob, A., Aranda-Mena, G., & Karamoozian, A. (2026). Artificial intelligence in BIM clash management: Assessment of current techniques, automation levels, and deployment readiness. Buildings, 16(13), 2623. https://doi.org/10.3390/buildings16132623

[2] Akande, O. (2010). Passive design strategies for residential buildings in a hot-dry climate in Nigeria. WIT Transactions on Ecology and the Environment. https://doi.org/10.2495/ARC100061

[3] Akram, V., Srivastav, A., Praveen, B., & Usmani, G. (2025). Does artificial intelligence promote financial inclusion? Evidence from developing countries. Journal of Economic Studies. https://doi.org/10.1108/JES-03-2025-0148

[4] Albukhari, I. (2025). The role of artificial intelligence (AI) in architectural design: A systematic review of emerging technologies and applications. Journal of Umm Al-Qura University for Engineering and Architecture, 16, 1–20. https://doi.org/10.1007/s43995-025-00186-1

[5] Chew, Z. X., Wong, J.-Y., Tang, Y. H., Yip, C., & Maul, T. (2024). Generative design in the built environment. Automation in Construction, 166, 105638. https://doi.org/10.1016/j.autcon.2024.105638

[6] Dileep, G., Ratna, M. V., & Kumar, G. V. (2025). Artificial intelligence in architecture: Opportunity, challenge, and responsibility. International Journal of Trend in Scientific Research and Development, 9(3). 846–851.

[7] Fan, Z., Chan, A. P. C., Darko, A., Chen, Z., & Li, D. (2022). Integrated applications of building information modeling and artificial intelligence techniques in the AEC/FM industry. Automation in Construction, 139, 104289. https://doi.org/10.1016/j.autcon.2022.104289

[8] Garba, B., Umar, M., Umana, A., Olu, J., & Ologun, A. (2024). Sustainable architectural solutions for affordable housing in Nigeria: A case study approach. World Journal of Advanced Research and Reviews, 23(3), 434–445. https://doi.org/10.30574/wjarr.2024.23.3.2704

[9] Givoni, B. (1998). Climate considerations in building and urban design. John Wiley & Sons.

[10] Intergovernmental Panel on Climate Change. (2023). Climate change 2023: Synthesis report. IPCC. https://www.ipcc.ch/report/ar6/syr/

[11] Ismail, U., Rabab, A., Majid, A., & Raed, A. (2024). Adoption of artificial intelligence in the construction industry in Saudi Arabia: Challenges and proposed solutions. International Journal of Social Science Humanity & Management Research, 3(11). https://doi.org/10.58806/ijsshmr.2024.v3i11n18

[12] Kambari, A. M., Abalaka, L. D., & Iorakaa, A. M. (2025). Integration of passive design strategies for thermal performance in the design of postgraduate hostel for Bingham University, Karu. International Journal of Engineering and Modern Technology, 11(9). DOI: 10.56201/ijemt.vol.11.no9.2025.pg186.195

[13] Kushwaha, J., & Gupta, J. (2026). Passive design strategies for primary school design in the composite climate of India. https://www.researchgate.net/publication/400341424_Passive_Design_Strategies_for_Primary_School_Design_in_Composite_Climate_of_India

[14] Lechner, N. (2015). Heating, cooling, lighting: Sustainable design methods for architects (4th ed.). John Wiley & Sons.

[15] Lere, H. M., & Bilkisu, H. (2025). AI-driven architectural design: Opportunities and ethical challenges. ARCN International Journal of Sustainable Development, 14(2), 97–110. https://arcnjournals.com/wp-content/uploads/2025/05/2726-4-573-1-1430-1.pdf

[16] Manmatharasan, P., Bitsuamlak, G., & Grolinger, K. (2025). AI-driven design optimization for sustainable buildings: A systematic review. Energy and Buildings, 332, 115440. https://doi.org/10.1016/j.enbuild.2025.115440

[17] Ming, H., Zhang, K., Nguyen, Q., & Tasdizen, T. (2023). The effects of passive design on indoor thermal comfort and energy savings for residential buildings in hot climates: A systematic review. Urban Climate, 49, 101466. https://doi.org/10.1016/j.uclim.2023.101466

[18] Miracle, A. H., Linda, E., & Emmanuel, K. X. (2026). Integrating affordable housing into climate adaptation and infrastructure investment planning: A scalable urban policy model. Energy and Environmental Research, 2(1), 1–11. https://doi.org/10.58614/eer211

[19] Negendahl, K. (2015). Building performance simulation in the early design stage: An introduction to integrated dynamic models. Automation in Construction, 54, 39–53. https://doi.org/10.1016/j.autcon.2015.03.002

[20] Olgyay, V. (2015). Design with climate: Bioclimatic approach to architectural regionalism (Updated ed.). Princeton University Press.

[21] Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., ... Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. BMJ, 372, n71. https://doi.org/10.1136/bmj.n71

[22] Rajput, T. S., & Thomas, A. (2022). Optimizing passive design strategies for energy-efficient buildings using hybrid artificial neural network (ANN) and multi-objective evolutionary algorithm through a case study approach. International Journal of Construction Management, 23, 1–13. https://doi.org/10.1080/15623599.2022.2056409

[23] Rane, N. (2023). Integrating building information modeling (BIM) and artificial intelligence (AI) for smart construction schedule, cost, quality, and safety management: Challenges and opportunities. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.4616055

[24] Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. Journal of Business Research, 104, 333–339. https://doi.org/10.1016/j.jbusres.2019.07.039

[25] Tahan, N., Banihashemi, S., & Bagheri-Moghaddam, F. (2026). Passive design strategies and innovative materials for net-zero energy buildings. Green Technologies and Sustainability, 4(3), 100399. https://doi.org/10.1016/j.grets.2026.100399

[26] Tang, Z. K., & Karadag, I. (2026). Machine learning for daylight performance prediction. Applied Sciences, 16(6), 2757. https://doi.org/10.3390/app16062757

[27] Tranfield, D., Denyer, D., & Smart, P. (2003). Towards a methodology for developing evidence-informed management knowledge by means of systematic review. British Journal of Management, 14(3), 207–222. https://doi.org/10.1111/1467-8551.00375

[28] United Nations. (2015). Transforming our world: The 2030 agenda for sustainable development. https://sdgs.un.org/2030agenda

[29] United Nations Environment Programme. (2023). 2023 global status report for buildings and construction. https://globalabc.org/resources/publications/2023-global-status-report-buildings-and-construction

[30] World Bank. (2023). Nigeria development update: Seizing the opportunity. World Bank. https://www.worldbank.org/en/country/nigeria
[31] Yang, Z. (2025). Integration of AI with building energy management systems for low-carbon urban development. Frontiers in Sustainable Development, 5, 104–119. https://doi.org/10.54691/y46pr676